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CONTENTS

ABSTRACT

Building and Fire Research Laboratory Publications, 1992 contains references to the publications prepared by the members of the Building and Fire Research Laboratory (BFRL) staff, by other National Institute of Standards and Technology (NIST) personnel for BFRL, or by external laboratories under contract or grant from the BFRL during the calendar year 1992.

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1. LITERATURE CITATIONS ARRANGED BY FIRST AUTHOR

1. Abib, A. H.; Jaluria, Y.
    Penetrative Convection in a Partially Open Enclosure.
    Rutgers, State University of New Jersey, New Brunswick
    American Society of Mechanical Engineers (ASME). Natural Convection in Enclosures.
    HTD-Vol. 192. 1992, Am. Soc. of Mechanical Engineers, New York, NY, 73-81 p, 1992.
    > enclosures; convection; heat sources; formulations; equations; stratification; flow fields; temperature; velocity distribution; penetration; heat transfer

    The penetrative convection induced by a localized heat source at the bottom of a partially open enclosure, while the background ambient medium is stably and thermally stratified, is considered. A rectangular cavity with a partially open side is assumed to be adjacent to a long corridor which is stably stratified. The stable thermal stratification that is of interest is a two-layered one or a linear temperature stratification. A control-volume finite-difference method, in stream function and vorticity formulation, is employed for the solution. The influence of the stratification parameter is examined in the laminar flow regime by considering a range of stratification levels. Heat transfer results, mass outflow rate, penetration distance, velocity and temperature distributions are presented to quantify the penetrative convection. It is found that, for a step ambient temperature profile, the convective motion occurring in the lower unstable layer penetrates significantly into the stable upper layer only for a weak stratification. Small penetration occurs at large stratification levels. The flow field reveals a multi-cellular pattern. Furthermore, it is observed that the penetrative motion occurs in the form of nearly horizontal motion in the lowest part of the stable upper-layer. The thermal field is studied in detail. Other important details on the penetrative transport are brought out.

2. Ames, S. A.; Babrauskas, V.; Parker, W. J.
    Upholstered Furniture: Prediction by Correlations.
    Fire Research Station, Borehamwood, England
    National Institute of Standards and Technology, Gaithersburg, MD
    Heat Release in Fires, Chapter 15, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 519-543 pp, 1992.
    > heat release rate; fire protection engineering; upholstered furniture; fire tests; fire behavior; upholstery; furniture calorimeters; large scale fire tests

    A detailed model for furniture combustion, of the sort described in the preceding chapter, represents the best-possible, state of the art calculation. For most purposes in design and evaluation, however, it is sufficient to obtain less accurate results, if they can be obtained by simple measurement techniques. In this Chapter we will examine large-scale measurements of heat release rates of upholstered furniture. Based on such measurements, we will introduce several techniques for predicting the essence of the full-scale behavior by judicious use of bench-scale test results.

3. Amos, B. T.
    Ignition and Flame Propagation Studies Over a Flat Fuel Surface.
    California Univ., Berkeley
    NIST-GCR-92-604;   148 p. March 1992.
    Available from National Technical Information Services
    PB92-181056
    > fuels; ignition; flame propagation; combustion; diffusion flames; premixed flames; radiation; surface temperature

    Numerical studies are performed which show the evolution of the combustion process over a flat fuel surface subjected to an external source of radiation. Ignition is caused either by the high temperature of the fuel surface or by radiation absorption by the fuel vapor. The surface is assumed to be either in a zero gravity, initially stagnant air environment or in a stagnation point flow field. Regardless of the source of ignition considered or the type of the flow field, the same sequence of events is predicted. This sequence of events begins with a pre-ignition, radiation dominated phase in which fuel and air mix above the fuel surface. After ignition occurs, there is a period of weak chemical reaction, which is

followed by a period of stronger reaction in which a premixed flame front develops. Before dying out the premixed flame front separates the fuel from the oxygen and leaves behind a diffusion flame. The combustion and radiation processes are shown to have a large effect on the flow field in the stagnation point flow cases. For the case in which ignition is caused by gas phase absorption, the radiation required to cause ignition is so high that an opposed jet flow is created. In the case in which ignition is caused by the hot fuel surface, the radiation is lower and the boundary layer remains almost intact. For both types of ignition the premixed flame fronts produced heat fast enough that the expanding gas is able to drive the incoming flow back from the fuel surface. After the premixed flame front dies out leaving the diffusion flame the incoming flow again dominates and a boundary layer reappears.

4. Babrauskas, V.
    Aircraft Applications. Part C. Comparative Heat Release Rates for Aircraft Materials
    Measured in Different Apparatuses.
    National Institute of Standards and Technology, Gaithersburg, MD
    Heat Release in Fires, Chapter 17, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
    S. J., Editors, 583-590 pp, 1992.

    heat release rate; fire protection engineering; aircraft compartments; test methods

It may seem surprising that there have not been a significant number of studies reported in the literature where results from 3 or more HRR apparatuses are directly compared against each other. The best-known such study was one by Ostman and co-workers in 1985. In that study three apparatuses were examined against a wide range of test materials. The application of these findings was somewhat limited, however, since two of the three methods studied (the STFI apparatus and the OSU apparatus modified for oxygen consumption sensing) were not standard equipment or procedures. Only the third apparatus, the Cone Calorimeter, was a common apparatus used in its standard form. More specifically, all three methods examined by Ostman used oxygen consumption as the measurement principles. Thus, differences seen between the apparatuses were due to such secondary effects as specimen size, sample holder arrangements, ignition mechanisms, and errors in calibration. The opportunity was still to come to subject a range to materials to apparatuses which differed in their very measurement principles, in addition to being of mechanically varied designs.

5. Babrauskas, V.
    Cone Calorimeter.
    National Institute of Standards and Technology, Gaithersburg, MD
    Heat Release in Fires, Chapter 4, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
    S. J., Editors, 61-91 pp, 1992.

    heat release rate; fire protection engineering; cone calorimeters; air flow; ignition; thickness; smoke
    measurement; reproducibility

For much of the bench-scale work carried out over the last few years, the Cone Calorimeter has been found by numerous laboratories to be the best tool for heat release rate measurement. It has also been designed to include a number of other measuring functions, including: effective heat of combustion; mass loss rate; ignitability; smoke and soot; and toxic gases.

6. Babrauskas, V.
    Cone Calorimeter Annotated Bibliography, 1982-1991.
    National Institute of Standards and Technology, Gaithersburg, MD
    NIST TN 1296;   53 p. September 992.
    Available from National Technical Information Services
    PB93-125094
    Available from Government Printing Office
    S-000-03175-5

    cone calorimeters; bibliographies; ASTM E 1354; fire tests; ISO 5660

An annotated bibliography is presented of published papers and reports on the topic of Cone Calorimeter apparatus, test data, and engineering applications of the test data. While most of the material surveyed is in English, the known foreign-language publications also are included. The annotations include a brief description of the work reported, however, the data are neither critically evaluated nor assessed.

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7.   Babrauskas, V.
        Effect of Environmental Variables.
        National Institute of Standards and Technology, Gaithersburg, MD
        Heat Release in Fires, Chapter 10, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
        S. J., Editors, 307-325 pp, 1992.

                heat release rate; fire protection engineering; environmental effects; oxygen concentration; ignition; flame spread;
                mass loss; combustion products; temperature; air; pressure; wind velocity; humidity; gravity
        We are primarily discussing fires that occur in buildings and under 'normal' conditions. But, clearly, some fires of great
        concern may not be in buildings; these include fires in submarines, spacecraft, and the like. The prevailing conditions will
        then, most likely, also be different for such fires. The variables which may be altered include: oxygen concentration in
        the combustion air; the temperature of the incoming combustion air; the presence of additional gases not occurring in
        normal air; total pressure; wind blowing across the burning object; relative humidity; and, the acceleration of gravity.

8.   Babrauskas, V.
        From Bunsen Burner to Heat Release Rate Calorimeter.
        National Institute of Standards and Technology, Gaithersburg, MD
        Heat Release in Fires, Chapter 2, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
        S. J., Editors, 7-29 pp, 1992.

                heat release rate; fire protection engineering; burners; calorimeters; small scale fire tests
        Fire performance of buildings, transportation vehicles, and other occupied spaces has traditionally been viewed as having
        two main aspects: flammability and fire endurance. Flammability (or, 'reaction to fire') is a very imprecise term, however,
        it normally includes ignitability, flame spread, and heat release rate. Fire endurance refers to the performance of the
        structure itself, that is, does it collapse during the fire, and do any of its internal compartment separations fail.

9.   Babrauskas, V.
        Full-Scale Heat Release Rate Measurements.
        National Institute of Standards and Technology, Gaithersburg, MD
        Heat Release in Fires, Chapter 5, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
        S. J., Editors, 93-111 pp, 1992.

                heat release rate; fire protection engineering; calorimetry; fire tests; cone calorimeters; furniture calorimeters
        The ability to accurately measure the heat being released by items such as burning furniture or industrial commodities,
        or by entire burning rooms, today is viewed as essential to fire protection engineering. While it is essential today, it is
        interesting to note that such a capability was not achieved successfully until the early 1980s, although there were some
        slightly earlier explorations. Indeed, the whole science of fire testing and fire modelling was greatly held back during the
        1970s due to the lack of this capability.

10.   Babrauskas, V.
        Full-Scale Three-Storey House Burned in Japanese Test.
        National Institute of Standards and Technology, Gaithersburg, MD
        Fire and Flammability Bulletin, 7-8, February 1992.
                fire tests; building fires; apartments; earthquakes
        On 4 December 1991 one of the most impressive full-building fire tests of recent history was conducted in Japan. The
        test building comprised a portion of a three-story apartment building and was built 1-1/2 units wide; that is to say, the
        test building included three complete apartments, flanked on one side by three smaller units.

11.   Babrauskas, V.
        Generation of CO in Bench-Scale Fire Tests and the Prediction for Real-Scale Fires.
        National Institute of Standards and Technology, Gaithersburg, MD

Interscience Communications Limited. Fire and Materials. International Conference, 1st. September 24-25, 1992, Arlington, VA, 155-177 pp, 1992.

carbon monoxide; cone calorimeters; fire hazard; toxicity; room fires; fire tests; scaling

Carbon monoxide (CO) is the single most important factor associated with deaths in fires; thus, predictions of CO developed in fires is an essential aspect of fire quantification. It is considered crucial to have correct CO prediction methods for post-flashover fire stages, since, in the United States at least, the majority of fire deaths are associated with fires which have gone to flashover. In this paper, it is shown that the yields of CO observed in real-scale fires are generally not related to either the chemical nature of the material being burned nor to the yield observed for the same material in bench-scale testing. Instead, the generation of CO in real-scale fires is determined largely according to the oxygen available for combustion, with thermal conditions of the fire plume also playing a significant role. This behavior is in sharp contrast to many other material fire properties, including yields of gases such as CO_2 and HCl, which can be predicted for real-scale fires from bench-scale results. Finally, results from various studies completed thus far indicate how effective prediction of real-scale CO yields may be accomplished. While bench-scale measurements are not necessary to predict real-scale CO, bench-scale toxic potency measurements can be in error if the CO component in them does not reflect on the real-scale CO yield. Thus, a method is developed whereby the bench-scale toxic potency measurements can be computationally corrected to better approximate the toxic potencies measured in real-scale, post-flashover room fires. These techniques will, undoubtedly, be further refined as additional experimental results become available.

12.   Babrauskas, V.
Handling Fire Data: The FDMS.
National Institute of Standards and Technology, Gaithersburg, MD
Heat Release in Fires, Chapter 18, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 591-607 pp, 1992.

heat release rate; fire protection engineering; fire data; computer programs

Prior to the coming of heat release rate tests, most fire tests had a relatively simple reporting format. Often, only the value of one particular variable was reported. It is true that with many of these traditional tests, the test report may not have been as simple as just one value being reported. Often, the test methods prescribed that a number of thermocouple channels, flame length distances, etc., be monitored and reported. Such reported data were, in fact, not useful nor used by the client or by the design professional. Instead, such ancillary measurements were only needed to document that the test laboratory carried out the test properly; if there were no improprieties noted, the additional information served no purpose.

13.   Babrauskas, V.
How Will Europe's Unified Standards Affect U. S. Building Products?
National Institute of Standards and Technology, Gaithersburg, MD
NFPA Journal, Vol. 86, No. 5, 45-49, September/October 1992.

standards; fire tests

It seems likely that the nations of the European Community will set the de facto product testing standards for the rest of the world.

14.   Babrauskas, V.
Plastics. Part B. The Effects of FR Agents on Polymer Performance.
National Institute of Standards and Technology, Gaithersburg, MD
Heat Release in Fires, Chapter 12, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 423-446 pp, 1992.

heat release rate; fire protection engineering; plastics; flame retardants; fire hazard; polyurethane foams; polystyrene; polypropylene; PMMA; cone calorimeters

Flame-retarded or fire-retarded polymers - what are they? The explanation seems simple: they produce 'slower' fires. But, is it simple? And what is 'slower', anyhow? Until very recently, to the polymer development chemist in the U. S., this performance did, indeed, seem simple. Such FR polymers were ones which performed better on the limiting oxygen index (LOI) or the UL 94 tests. Unfortunately, there has been no evidence to show that the LOI test has any correlation with actual fire performance. The UL 94 Bunsen burner test, by contrast, does represent fairly realistically the ignition of small plastic parts from small ignition sources. Despite this limitation, it is most commonly

used as a general test for rating plastics, such as large sheets, which are associated with very different hazard issues. So, FR polymers show retarded fire development in some limited or irrelevant bench-scale tests. What about real fire performance? Can they show improved ignitability, flame spread rates, heat release rates, smoke evolution, etc.? There are no theoretical or systematic answers to these questions. Thus, in this section we will, instead, review some of the experimental data useful for answering such questions.

15. Babrauskas, V.
Related Quantities. Part A. Heat of Combustion and Potential Heat.
National Institute of Standards and Technology, Gaithersburg, MD
Heat Release in Fires, Chapter 8, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 207-223 pp, 1992.

> heat release rate; fire protection engineering; heat of combustion; potential heat

In a combustion reaction, the essential quantity is the heat of reaction. Since in typical combustion reactions we are dealing with constant-pressure, rather than constant-volume systems, it is more convenient to work with enthalpies, rather than energies. The enthalpy, H (kJ), is defined as: $H = U + PV$ where U is the energy (kJ), P is the pressure (kPa), and V is the volume (m^3). In thermodynamics and engineering calculations, specific enthalpy, h, is often used (and also specific energy, u). Molar units (kJ/mol) for those terms are typical in thermodynamics calculations, while in engineering computations it is often convenient to adopt mass (kJ/kg) units.

16. Babrauskas, V.
Related Quantities. Part D. Gas Species Measurement.
National Institute of Standards and Technology, Gaithersburg, MD
Heat Release in Fires, Chapter 8, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 251-255 pp, 1992.

> heat release rate; fire protection engineering; smoke; soot; production rate; large scale fire tests

What gas species, besides oxygen, might we wish to measure? Primarily, we are interested in either those which can serve as combustion diagnostics (e.g., H_2O, CO_2, total unburned hydrocarbons) or those which are of interest from a toxicity point of view (e.g., CO, HCl, HBR, HF, HCN, NO_2). The instrumentation for making gas species measurements was already discussed in Chapter 3 above. Here, we wish to consider how the data might be used, once obtained.

17. Babrauskas, V.
Simple Cases of Heat Release Rates. Part B. Pools.
National Institute of Standards and Technology, Gaithersburg, MD
Heat Release in Fires, Chapter 7, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 201-206 pp, 1992.

> heat release rate; fire protection engineering; pool burning; thermoplastics; equations; burning rates

The burning of liquid droplets and spheres considered in the previous section is instructive, since these are cases for which theoretical solutions may be directly obtained. The next more complex, yet still 'simple' case is of the liquid (or thermoplastic) pool. Over the last 3 or so decades, an enormous number of studies have been conducted where pool burning was considered theoretically or measured empirically. The most systematic early study was by two Russian researchers, Blinov and Khudiakov.

18. Babrauskas, V.
Toxicity, Fire Hazard and Upholstered Furniture.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd. European Conference on Furniture Flammability, 3rd. 1992, Brussels, Interscience Communications Ltd., London, England, 125-133 pp, 1992.

> upholstered furniture; toxicity; fire hazard; combustion products; hazard analysis; heat release rate

Fire fatalities associated with upholstered furniture fires commonly involve the toxic effects of fire gases. Extensive results, however, both from experiments and from modeling, are presented in this paper that demonstrate that occupant life safety can only be ensured by assuring that furniture fires do not reach a high heat release rate. Differences among commercial

products associated with toxicity effects are not significant. A very remote possibility exists that someone could produce furniture having combustion products' toxicity significantly greater than exists in the present marketplace. A combustion toxicity test does exist which would allow the accurate screening out of such products. Any usable combustion toxicity test method requires the use of test animals; no non-animal-based test is possible which can successfully identify products of unusual or extreme toxicity.

19.   Babrauskas, V.; Grayson, S. J., Editors
      National Institute of Standards and Technology, Gaithersburg, MD
      London Univ., England
      Heat Release in Fires, Elsevier Applied Science, NY, 656 pp, 1992.
              heat release rate; fire protection engineering

20.   Babrauskas, V.; Levin, B. C.; Gann, R. G.; Paabo, M.; Harris, R. H., Jr.; Peacock, R. D.; Yusa, S.
      Measurement of Toxic Potency for Fire Hazard Analysis.
      National Institute of Standards and Technology, Gaithersburg, MD
      Building Research Inst., Tsukuba, Japan
      Congres Mondial du Batiment. Poster Book - Recueil d'affiches. Tome 2. Topics 3A. to 3D., 4A. to 4E. and 5A. to 5E. CIB 92. May 18-22, 1992, CIB 92, Montreal, Canada, 436-437 pp, 1992.
              fire research; hazard analysis; smoke; toxicity; combustion; toxic hazards
      This study is the principle product of a research program to provide a technically sound methodology for obtaining and using smoke toxicity data for hazard analysis. It establishes: (a) an improved bench-scale toxic potency measurement, one which represents the important combustion conditions of real fires; and (b) a design and analysis framework which will allow the toxic potency data to be used in a rational, consistent, appropriate, and adequate way. This establishment of proper bench-scale test conditions, validation of the output against real-scale fire measurements, and development of a consistent framework for fire hazard analysis is unique and represents a successful, usable implementation of the state of the art.

21.   Babrauskas, V.; Peacock, R. D.
      Heat Release Rate: The Single Most Important Variable in Fire Hazard.
      National Institute of Standards and Technology, Gaithersburg, MD
      Fire Safety Journal, Vol. 18, No. 3, 255-272, 1992.
      Fire Retardant Chemicals Association (FRCA). Fire Safety Developments and Testing: Toxicity--Heat Release--Product Development--Combustion Corrosivity. Fall Meeting, 1990. October 20-25, 1990, Ponte Vedra Beach, FL, FRCA, Lancaster, PA, 67-80 pp, 1990.
              heat release rate; fire hazard; fire endurance; building fires; fire tests
      Heat release rate measurements are sometimes seen by manufacturers and product users as just another piece of data to gather. It is the purpose of this paper to explain why heat release rate is in fact, the single most important variable in characterizing the 'flammability' of products and their consequent fire hazard. Examples of typical fire histories are given which illustrate that even though fire deaths are primarily caused by toxic gases, the heat release rate is the best predictor of fire hazard. Conversely, the relative toxicity of the combustion gases plays a smaller role. The delays in ignition time, as measured by various Bunsen burner type tests, also have only a minor effect on the development of fire hazard.

22.   Babrauskas, V.; Twilley, W. H.; Janssens, M.; Yusa, S.
      Cone Calorimeter for Controlled-Atmosphere Studies.
      National Institute of Standards and Technology, Gaithersburg, MD
      Fire and Materials, Vol. 16, No. 1, 37-43, January/March 1992.
              cone calorimeters; controlled atmospheres; test methods; combustion chambers
      Many fires occur in ambient atmospheric conditions. To investigate certain types of fires, however, it is necessary to consider combustion where the oxidizer is not 21% oxygen/79% nitrogen. The Cone Calorimeter (ASTM E 1354, ISO

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DIS 5660) has recently become the tool of choice for studying the fire properties of products and materials. Its standard use involves burning specimens with room air being drawn in for combustion. To facilitate studying fires involving different atmospheres, a special version of the Cone Calorimeter was designed. This unit allows controlled combustion atmospheres to be created by the use of bottled or piped gases. To make such operation feasible, a large number of design details of the standard calorimeter had to be modified. This paper describes the background for these changes and provides an explanation of how the controlled-atmospheres unit is operated.

23.   Babrauskas, V.; Urbas, J.; Richardson, L.
       Related Quantities. Part E. Non-Combustibility.
       National Institute of Standards and Technology, Gaithersburg, MD
       University of Ljubljana, Yugoslavia
       Forintek Canada Corp., Ottawa, Ontario
       Heat Release in Fires, Chapter 8, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
       S. J., Editors, 257-264 pp, 1992.

            heat release rate; fire protection engineering; test methods; noncombustion; cone calorimeters; building codes;
            specifications
       In a true fire-engineering sense the word 'non-combustibility' would be just as deprecated as the term 'fireproof' is today.
       Nonetheless, the term is widely used in building codes. The provisions in various countries and jurisdictions vary widely;
       the majority, however, are based on a 'non-combustibility' test. The most common non-combustibility test is ISO 1182.
       A method using rather similar principles, but a different furnace, is the ASTM E 136 test. Some years ago, ASTM did
       decide that 'non-combustibility' was a misleading name, and so changed the name of E 136 from its original 'Standard
       Test Method for Non-Combustibility of Elementary Materials' to its present name, Standard Test Method for Behavior
       of Materials in a Vertical Tube Furnace at 750 deg C. The concept, however, was not altered. Both the ISO and the
       ASTM methods equip a small specimen with several thermocouples, then insert it into a hot furnace. A differential
       temperature rise of more than the allowed amount is the primary failure criteria; other criteria include observations of
       flaming and measurement of mass loss.

24.   Bailey, D. M.; Rossiter, W. J.; Seiler, J. F., Jr.
       Three-Year Field Test Summary for Experimental Modified Bitumen Roofing at Fort Polk,
       LA.
       Army Construction Engineering Research Labs., Champaign, IL
       National Institute of Standards and Technology, Gaithersburg, MD
       FM-93/05;   34 p. December 1992.
       Available from National Technical Information Services

            roofing (finishes); bitumens; construction; tests; mechanical properties; physical
            properties; inspection; technology transfer
       This report presents results of the first 3 years of a 10-year field evaluation on three modified bitumen roofing systems
       at Fort Polk, LA. This work is part of a research effort being conducted by the U. S. Army Construction Engineering
       Research Laboratories (USACERL) to attempt to identify alternative, easy-to-install roofing systems that can improve
       the performance of Army roofing while reducing life-cycle costs. Three different modified bitumen roofing systems were
       installed on Building 920 at Fort Polk. At the time of installation, researchers tested the roof membrane materials for
       initial properties to provide a basis for comparison with later samples. Test samples for each roofing system
       were removed annually for 3 years and the sample section was patched. Properties of the membrane material evaluated
       are those considered essential to good roofing performance. For most properties, American Society of Testing and
       Materials (ASTM) standard test methods are used. In addition, the roofs are inspected visually once each year.
       Preliminary findings indicate that the test roofs are performing excellently.

25.   Bentz, D. P.; Garboczi, E. J.
       Computer Modeling of Cement-Based Materials.
       National Institute of Standards and Technology, Gaithersburg, MD
       Cray Channels, 12-16, Summer 1992.

            computer models; cements; microstructure; macroscopic properties

Cement-based materials are among the most widely used construction materials in the world. Their importance is highlighted by the recent establishment of research initiatives by the National Science Foundation and the Strategic Highway Research Program. The National Science Foundation Science and Technology Center for Advanced Cement-Based Materials (ACBM) is a consortium of five institutions: Northwestern University, the University of Illinois at Champaign-Urbana, Purdue University, the University of Michigan, and the National Institute of Standards and Technology (NIST). The center's goal is to increase the understanding of cement-base materials to establish the scientific basis for developing new, high-performance classes of these materials.

26. Bentz, D. P.; Garboczi, E. J.
Guide to Using HYDRA3D: A Three-Dimensional Digital-Image-Based Cement Microstructural Model.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4746; 95 p. January 1992.
Available from National Technical Information Services
PB92-148254

> cements; computer programs; computer models; hydration; interfacial zone; microstructure; percolation; simulation; software

A computer program, HYDRA3D, to simulate cement microstructural development and quantify microstructural characteristics has been developed. HYDRA3D is a menu driven program available in either Fortran or C which allows a user to create a starting microstructure, execute hydration, measure phase fractions, and assess phase connectivity. This manual outlines the conceptual model on which HYDRA3D is based, describes the programs in detail, and provides examples of program usage. A system calling diagram, source code listings, guidelines for modifying the programs, and system requirements are provided in the Appendices.

27. Bentz, D. P.; Garboczi, E. J.
Modelling the Leaching of Calcium Hydroxide From Cement Paste: Effects on Pore Space Percolation and Diffusivity.
National Institute of Standards and Technology, Gaithersburg, MD
Materials and Structures, Vol. 25, 523-533, 1992.

> paste; cements; leaching; calcium hydroxide; percolation; diffusivity; microstructure; degradation

As concrete is exposed to the elements, its underlying microstructure can be attacked by a variety of aggressive agents. For example, rainwater and groundwater can degrade the concrete by dissolving soluble constituents such as calcium hydroxide. Using computer simulation, this paper examines the effects of calcium hydroxide dissolution on two material properties: the percolation properties or connectivity of the capillary pore space, and the relative ionic diffusivity. A microstructural model for cement paste is used to produce a hydrated specimen which is subsequently subjected to the leaching process. Pore space percolation characteristics and relative ionic diffusivity are computer throughout the leaching process as a function of total capillary porosity. Material variables examined are water:solids ratio and silica fume content. Percolation theory is used to develop the concept of a critical volume fraction of calcium hydroxide plus capillary pore space. It is shown that this critical combined volume fraction determines the magnitude of the effect of leaching on relative ionic diffusivity.

28. Bentz, D. P.; Garboczi, E. J.; Stutzman, P. E.
Computer Modelling of the Interfacial Zone in Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
RILEM. Interfaces in Cementitious Composites. International Conference. Proceedings 18. October 21-23, 1992, Toulouse, France, E & FN Spon, New York, Maso, J. C., Editor, 107-116 pp, 1992.

> concretes; computer models; aggregates; cements; hydration; clinker; interfacial zone; microstructure; mineral admixture; simulation

A digital-image-based microstructural model is applied to simulating cement paste-aggregate interfacial zone microstructural development in a variety of concretes. A starting model system consists of a single spherical cement and

mineral admixture particles. A cement hydration model based on a cyclic process of dissolution, diffusion, and reaction is utilized to hydrate starting microstructures. In addition to supporting the well known wall effect, the model has suggested that a "one-sided growth" effect also contributes to the microstructural features developed in interfacial zones. The effects of mineral admixture particle size and reactivity and those of aggregate reactivity and water absorptivity on interfacial microstructure are explored via simulation. In many cases, it appears that improvements in the uniformity and density of the interfacial zone microstructure can be achieved by controlling these properties. Quantitative validation of the model is obtained by comparing model systems to ones prepared in the laboratory for concretes containing 0, 10, and 20% silica fume. Good agreement between the two systems is observed.

29. Bentz, D. P.; Martin, J. W.
Thermographic Imaging of Surface Finish Defects in Coatings on Metal Substrates.
National Institute of Standards and Technology, Gaithersburg, MD
Materials Evaluation, Vol. 50, No. 2, 242-246, February 1992.

coatings; substrates; metals; heating; temperature; thickness

A technique for detecting and quantifying coating surface defects is presented. The technique is based on heating the coating system slightly above ambient temperature and viewing it with an infrared thermography camera attached to a computer image processor. Surface finish defects are visible in the resultant thermographic image due to coating thickness variations between the defect and nondefect areas. These thickness variations influence the thermal radiation emission/reflection/transmission properties of the coating system detected by the thermographic camera. The theory for a model coating system is presented and several application areas explored. Theoretical limitations on the use of this technique are discussed.

30. Bentz, D. P.; Stutzman, P. E.; Garboczi, E. J.
Experimental and Simulation Studies of the Interfacial Zone in Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
Cement and Concrete Research, Vol. 22, 891-902, 1992.

concretes; cements; interfacial zone; mineral admixture particles; experiments; qualitative analysis

Since concrete is a composite material, the interfaces between components can be expected to have major effects on physical properties. In ordinary portland cement concrete, the interfacial zone between cement paste and aggregate has been shown to exhibit characteristics greatly differing from those of the bulk paste. The addition of mineral admixtures to the mix has been shown to significantly alter this interfacial zone between cement paste and aggregate has been shown to exhibit characteristics greatly differing from those of the bulk paste. The addition of mineral admixtures to the mix has been shown to significantly alter this interfacial zone microstructure and enhance physical properties of the composite. In this paper, a direct comparison is made between results obtained using a three-dimensional microstructural model and those obtained experimentally on a similar set of mixes containing various amounts of silica fume. Quantitative measurements of backscattered electron images of the interfacial zone in the real materials are compared to model results. The model reproduces the experimentally-observed characteristics of the interfacial zone, which are quite different with and without the presence of silica fume. Based on the model and experimental results, it is suggested that the presence of silica fume produces a more homogeneous microstructure by balancing the Ca/Si molar ratio in the interfacial zone relative to that in the bulk paste, unlike ordinary portland cement concrete where this ratio increases dramatically as the aggregate surface is approached.

31. Beyler, C. L.
Technical Review of the Furniture Fire Model Version 3.
Hughes Associates, Inc., Columbia, MD
NIST-GCR-92-618; 23 p. October 1992.
Available from National Technical Information Services
PB93-125052

computer models; fire models; fire research; furniture; mathematical models

This paper reviews the furniture fire model and the documentation of the model in terms of its adequacy, accuracy, generality, and validity. Individual elements of the model are assessed as well as overall modeling approach. Serious deficiencies in the model are identified which make it of little value in its present form. Many of the submodels used have not been validated by comparison with literature data, and these submodels differ substantially from well accepted methods in the literature. This brings into question the correctness of the model and its relation to the state-of-the-art. The model has a large number of inputs which are not determined by definite procedures. The documentation of the model is highly fragmented and incomplete. These attributes seriously compromise the validity and usefulness of the model. Extensive work would be required to make the model useful in hazard evaluations. These include extensive validation of submodels, evaluations of the adequacy of the overall program including experimental and numerical experimentation, and definition of methods for developing the inputs required.

32.   Braun, E.; Lowe, D. L.; Jones, W. W.; Tatem, P.; Bailey, J.; Carey, R.
       Comparison of Full Scale Fire Tests and a Computer Fire Model of Several Smoke Ejection
       Experiments.
       National Institute of Standards and Technology, Gaithersburg, MD
       Naval Research Laboratory, Washington, DC
       David Taylor Naval Ship Research and Development Center, Annapolis, MD
       NISTIR 4961;   43 p. November 1992.
       Available from National Technical Information Services
       PB93-139087

          compartment fires; fire growth; mathematical models; numerical models; room fires; smoke; toxicity
       Data were obtained from four large scale shipboard fire tests. The test series was designed to evaluate the efficacy of
       a smoke ejection system for the removal of smoke and heat from compartments around the compartment of fire origin.
       Using diesel oil and polyethylene beads as fuel, tests were conducted at 0.5 MW and 1.0 MW. The data obtained
       from these tests were evaluated in terms of the reduction of heat and smoke in adjacent passageways. These results were
       compared to numerical simulations of the shipboard environment. The test results showed that the atmospheric conditions
       in compartments/passageways adjacent to the compartment of fire origin could be made survivable by isolating the fire
       compartment and ventilating adjacent spaces. It was found that, under the ventilation conditions of these tests, effective
       reduction in smoke and heat from peak values to ambient values took 350 to 400 s, depending on the
       compartment's proximity to the door of the compartment of fire origin. Comparisons with
       the numerical simulation showed that we can predict the environment which develops with
       reasonable confidence.

33.   Brewer, J. N., Jr.
       Standards Referenced in Model, State, and City Building Codes.
       National Institute of Standards and Technology, Gaithersburg, MD
       NISTIR 4952;   472 p. September 1992.
       Available from National Technical Information Services
       PB93-120814

          building codes; regulations; building regulatory systems; building technology; standards; standards organizations
       This publication provides a listing of the standards that are referenced in the building codes promulgated by: (1) the three
       model building code organizations; i.e., Building Officials and Code Administrators International, Inc. (BOCA),
       International Conference of Building Officials (ICBO), and the Southern Building Code Congress International, Inc.
       (SBCCI); (2) the 29 states that have mandatory state building codes; and (3) 35 selected U. S. cities. In addition to
       identifying each standard referenced in the above-named codes, this publication lists the current date of the standard, its
       title, the codes referencing it, the date of the code, the locations within the code where the standard is referenced, and
       the date of the standard referenced in the code. This publication is intended to provide assistance to the building
       community in updating, using and maintaining the standards referenced in building codes.

34.   Brown, J. E.
       Plastics. Part C. Composite Materials.
       National Institute of Standards and Technology, Gaithersburg, MD
       Heat Release in Fires, Chapter 12, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,

S. J., Editors, 447-459 pp, 1992.

> heat release rate; fire protection engineering; plastics; composite materials; ignition; gasification; reinforced plastics

A composite is a combined material created by synthetic assembly of two or more components - a selected filler or a reinforcing agent and a compatible binder (i.e., a resin) in order to obtain specific characteristics and properties. Methodologies of composite fabrication and the resulting properties are described in detail in a number of comprehensive works, such as those of Lubin, Grayson, and the ASM International Handbook. Moreover, the chemical and physical properties of the resins, reinforcement fibers and fillers are delineated both as individual components and in the finished material. The composite materials in this chapter, for the most part, consist of fiber reinforced resins and are frequently called reinforced plastics (RP or FRP).

35. Bryner, N.; Richards, C.D.; Pitts, W. M.
Rayleigh Light Scattering Facility for the Investigation of Free Jets and Plumes.
National Institute of Standards and Technology, Gaithersburg, MD
Review of Scientific Instruments, Vol. 63, No. 7, 3629-3635, July 1992.

> rayleigh light scattering; buoyant plumes; lasers; clean room fires; turbulent flow; scattering coefficient; construction

A Rayleigh light scattering facility (RLSF) has been developed and successfully used to examine mixing in free jets and buoyant plumes. The RLSF couples laser diagnostics with a cylindrical clean room, test section diameter of 2.4 m and a height of 2.4 m, to monitor the real-time concentration behavior within turbulent flows. The facility has been carefully designed to minimize interferences of glare and Mie scattering by suppressing background light and removing dust particles. The relatively large working section of the RLSF allows quantitative concentration measurements via Rayleigh light scattering (RLS) in free shear flows entering quiescent surroundings. As a result, RLS measurements are now possible in momentum-driven flows for conditions which were impossible in the past and in buoyancy-driven flows for which no previous RLS investigations have been made. Initial measurements of concentration in momentum-driven jet flows of helium and Freon-13 and a transitional (momentum- to buoyancy-driven) jet of Freon-13 demonstrate the advantages of the new RLSF.

36. Building Center of Japan (MOC); Raufaste, N. J.
Earthquake Resistant Construction Using Base Isolation. Earthquake Protection in Buildings Through Base Isolation.
Building Center of Japan
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 832 Vol. 1; 161 p. April 1992.
Available from Government Printing Office
SN003-003-03155-1
Available from the National Technical Information Service
PB92-189562

> earthquakes; active damper; base isolation; damping; devices; evaluation; passive damper; performance; seismic; structures; wind loads

This is Volume 1 of a two volume series on Energy Dissipating systems for buildings and other structures. This volume, Earthquake Protection in Buildings Through Base Isolation describes energy dissipating systems and reviews their applications and effectiveness. The documents include guidelines for evaluating energy dissipating systems and a directory of the systems used in buildings and other structures. The two volume reports were produced by the Building Center of Japan under sponsorship of the Japanese Ministry of Construction (MOC) to describe the state-of-art energy dissipating systems and to review their use in mitigating damages from earthquakes. The subjects addressed in these reports include: the history and types of passive energy dissipators; their applications, evaluations, and performance; and case histories of these systems exposed to seismic loading.

37. Building Center of Japan (MOC); Raufaste, N. J.
Earthquake Resistant Construction Using Base Isolation. Survey Report on Framing of the Guidelines for Technological Development of Base-Isolation Systems for Buildings.

Building Center of Japan
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 832 Vol. 2;   575 p. April 1992.
Available from Government Printing Office
SN003-003-03154-2
Available from the National Technical Information Service
PB92-189570

> earthquakes; active damper; base isolation; damping; devices; evaluation; passive damper; performance; seismic; structures; wind loads

This report is Volume 2 of a two volume series on passive energy dissipating systems for buildings and other structures. This volume, Survey Report on Framing of the Guidelines in Technological Development of Base Isolation Systems for Buildings, addresses the performance of these systems and provides examples of buildings installed with the systems. The documents provide guidelines for evaluating these systems and a directory of these systems used in buildings and other structures. The original reports in Japanese were published by the Building Center of Japan under the sponsorship of the Japanese Ministry of Construction (MOC). The MOC provided these reports to the National Institute of Standards and Technology for their translation into English and for publication. The subjects addressed in these reports include: the history and types of passive energy dissipators; their applications, evaluations, and performance; and case histories of these devices exposed to seismic loading.

38.   Bukowski, R. W.; Spetzler, R. C.   92-00594
Analysis of the Happyland Social Club Fire With HAZARD I.
National Institute of Standards and Technology, Gaithesburg, MD
Fire and Arson Investigator, Vol. 42, No. 2, 36-47, March 1992.
Journal of Fire Protection Engineering, Vol. 4, No. 4, 117-131, 1992.

> hazard assessment; building fires; fire hazard; computer programs; hazard analysis; sprinklers; stairways; exits; costs; tenability limits; temperature; energy transfer; oxygen concentration; carbon monoxide; fire investigations

In the early morning hours of March 25, 1990 a tragic fire took the lives of 87 persons at a neighborhood club in the Bronx, New York. A few days later, the New York City Fire Department requested the assistance of the Center for Fire Research (CFR) in understanding the factors which contributed to this high death toll and to develop a strategy that might reduce the risk of a similar occurrence in the many similar clubs operating in the city. It was not the purpose of the CFR work to examine cause and origin, nor criminal or negligent actions which may or may not have taken place before or after the incident. In responding to this request, CFR staff visited the fire scene on March 29 to obtain information needed to perform an analysis with the HAZARD I Fire Hazard Assessment Method. Physical measurements taken on site along with floorplan drawings and newspaper accounts provided the only data on which this analysis was based. No material samples were taken and no testing was performed.

39.   Bukowski, R. W.
Simple Tools: The Equations. Session 4 - The Tools.
National Institute of Standards and Technology, Gaithersburg, MD
CSIRO. International Fire Safety Engineering Conference. Concept and the Tools.
Presented for FORUM for International Cooperation on Fire Research. Supported by SFPE, NFPA, AFPA, AAFA. October 18-20, 1992, Sydney, Australia, 1-8 pp, 1992.

> fire safety; safety engineering; equations; computer programs; fire hazards; fire models; fire protection

The paper reviews the development and current state of calculational tools for fire safety engineering, particularly algebraic equations and simple models, in relation to the more complex zone and field models also being used in practice. Examples of some of the more common relations are presented along with a discussion of their important limitations. Some comments on accuracy and precision are included.

40.   Bukowski, R. W.; Tanaka, T.
Toward the Goal of a Performance Fire Code.
National Institute of Standards and Technology, Gaithersburg, MD
Building Research Inst., Tsukuba, Japan

Fire and Materials, Vol. 15, No. 4, 175-180, October/December 1991.
CSIRO. International Fire Safety Engineering Conference. Concept and the Tools.
Presented for FORUM for International Cooperation on Fire Research. Supported by
SFPE, NFPA, AFPA, AAFA. October 18-20, 1992, Sydney, Australia, 1992.

> fire codes; regulations; fire safety; simulation; safety factors; heat release rate; fuel load; fire growth

The paper presents a strategy for the development and implementation of performance-based fire codes on an international scale. The process begins with agreement on a common set of goals which underline the code. Existing code bodies then decide on an appropriate set of quantitative prediction tools with which they are comfortable, and use them to quantify the degree to which their current code addresses these goals by establishing a standard design fire for each occupancy. By applying standard safety criteria and safety factors appropriate to the choice of predictive methods, the performance of any building can be quantified against the stated goals. To allow for an orderly transition from current codes, an interim code structure under which currently acceptable methods are 'deemed to satisfy' the code is presented.

41.   Burch, D. M.
Controlling Moisture in the Roof Cavities of Manufactured Housing.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4916;   50 p. November 1992.
Available from National Technical Information Services
PB93-139046

> roofs; housing; attic ventilation; HUD Manufactured Home Construction; safety standards; mobile homes; moisture control guidelines; moisture in attics

A detailed computer analysis is conducted to investigate whether moisture problems occur in the roof cavity of manufactured homes constructed in compliance with the current Department of Housing and Urban Development (HUD) Standards for manufactured housing. The current HUD Standards require a ceiling vapor retarder, but do not require outdoor ventilation of the roof cavity. In cold climates, the analysis revealed that moisture accumulates at lower roof surface and poses a risk of material degradation. The analysis found the following combination of passive measures to be effective in preventing detrimental winter moisture accumulation at lower surface of the roof: 1) providing a ceiling vapor retarder, 2) sealing penetrations and openings in the ceiling construction, and 3) providing natural ventilation of the roof cavity. In addition, the performance of a roof cavity subjected to a hot and humid climate is investigated. The analysis revealed that outdoor ventilation of the roof cavity causes the monthly mean relative humidity at the upper surface of the vapor retarder to exceed 80%. This condition is conducive to mold and mildew growth.

42.   Burch, D. M.; Seem, J. E.; Walton, G. N.; Licitra, B. A.
Dynamic Evaluation of Thermal Bridges in a Typical Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
Johnson Controls Inc., Milwaukee, WI
ASHRAE Transactions, Vol. 98, No. 1, [pages unknown], January 1992.

> office buildings; abridges (structures); steady-state; finite difference theory; heat transfer; computer programs

A finite-difference model is used to predict the steady-state dynamic thermal performance of thermal bridges in a typical office building. The thermal bridges evaluated include a built-up roof system with ceiling fasteners, a roof/wall interface, an insulated masonry cavity wall with metal studs, a floor slab that penetrates wall insulation, and a window frame/wall interface. The steady-state analysis reveals that these typical thermal bridges increased the overall envelope heat transfer coefficient for the office building by 33%. A thermal bridge is found to have a large effect when it has a large cross-sectional area that short-circuits the thermal insulation of the building envelope. In the dynamic analysis, a finite-difference model is used to numerically determine a complete set of conduction transfer function (CFT) coefficients for each of the thermal bridges. The mathematical procedure is to predict the heat-transfer response of a thermal bridge when it is excited by a ramp excitation function. The heat transfer response for a triangular pulse is subsequently obtained by superimposing the responses for three ramp excitation functions to form a triangular pulse. A recursive relation, employing a past-history CTD, is applied to the triangular-pulse response to determine first-order CTF coefficients. The validity of the CFT coefficients is demonstrated by accurately predicting the heat-transfer response of each of the thermal bridges to a diurnal indoor and outdoor temperature cycle. Mathematical procedures are described

to remove the air film resistances from the numerical CFT coefficients, thereby permitting them to be incorporated into computer programs that predict space heating and cooling loads for buildings.

43.   Burch, D. M.; Thomas, W. C.; Fanney, A. H.
        Water Vapor Permeability Measurements of Common Building Materials.
        National Institute of Standards and Technology, Gaithersburg, MD
        Virginia Polytechnic Inst., Blacksburg
        American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). Annual Meeting, 1992. Technical and Symposium Papers. ASHRAE Transactions, Volume 98, Part 2, 1992. June 27-July 1, 1992, BA-92-6-2, Baltimore, MD, ASHRAE, Atlanta, GA, 486-494 pp, 1992.

    water vapor; building materials; permeability; cup method; humidity; temperature effect

A cup method was used to measure water-vapor transmission in 10 common building materials. The materials included sugar pine, sturdy-brace fiberboard, fiberboard sheathing, particleboard, exterior-grade plywood, plain gypsum board, kraft paper, waferboard siding, vinyl-covered gypsum board, and foam core sheathing. For each material, a series of cup measurements was conducted, and the permeability (or permeance) was plotted as a function of the mean relative humidity across the specimen. Separate measurements, carried out at 24 deg C (75 deg F) and 7 deg C (44 deg F), indicated that temperature has an insignificant effect on permeability. The permeability measurements were compared with other measurements reported in the literature, and the agreement was good in most cases.

44.   Bushby, S. T.
        Formal Analysis of the BACnet MS/TP Medium Access Control Protocol.
        National Institute of Standards and Technology, Gaithersburg, MD
        NISTIR 4777;   25 p. April 1992.
        Available from National Technical Information Services

    BACnet; building automation; CMSV; formal model; communication protocol

BACnet, a draft standard communication protocol for building automation and control systems, contains options for physical and data link layer protocols. One option is to use an EIA-485 physical layer combined with a Master-Slave/Token Passing (MS/TP) media access control protocol which was specifically designed for BACnet. This paper presents a formal model of the MS/TP protocol using the technique of communicating machines with shared variables. Using this model, the protocol is analyzed and shown to be deadlock free. It is also shown that if a controller has a message to send it will eventually be transmitted.

45.   Carino, N. J.
        Performance of Electromagnetic Covermeters for Nondestructive Assessment of Steel Reinforcement.
        National Institute of Standards and Technology, Gaithersburg, MD
        NISTIR 4988;   131 p. December 1992.
        Available from National Technical Information Services

    covermeter; building technology; concretes; eddy current; electromagnetic device; magnetic reluctance; nondestructive testing; reinforcing bars

Covermeters are electromagnetic devices for locating steel reinforcing bars in concrete structures. An experimental study was carried out to compare the basic characteristics of two types of commercial covermeters (magnetic reluctance and eddy current). Experiments were carried out using single bars and multiple bars with various configurations. One group of single-bar tests studied the relationships between meter reading and cover thickness. Empirical equations were fitted to the data, and the values of the equation parameters were found to be relatively insensitive to the bar size. The other group of single-bar tests examined the relationship between meter reading and horizontal distance between the meter probe and the bar axis (offset). Data were fitted with a bell shaped, quadratic exponential function. The parameter characterizing the decay of the meter reading with offset was found to depend on the cover in a well-defined manner. This parameter was used to characterize the differences in the influence zones of the probes. Tests with multiple, parallel bars were conducted to determine the critical spacings below which the location of the individual bars could not be discerned and below which the meter amplitude exceeded the single-bar value. A simple summation model was used to

predict the response based on the individual-bar response. Criteria were proposed to estimate these critical spacings based upon the single-bar responses. Other tests showed that the meters cannot discern a bar located directly below another bar. The ability of the meters to locate the ends of bars was also investigated, and the eddy-current meter appeared superior for this purpose. The final series of tests examined the ability of the meters to measure the length of a lap splice, and the meter based upon magnetic reluctance appeared superior for this purpose. Recommendations for developing a standard test method and for improvements in meter performance are provided.

46. Carino, N. J.; Knab, L. I.; Clifton, J. R.
     Applicability of the Maturity Method to High-Performance Concrete.
     National Institute of Standards and Technology, Gaithersburg, MD
     NISTIR 4819;   64 p. May 1992.
     Available from National Technical Information Services
     PB93-157451

     concretes; curing; silica; fumes; temperature; maturity method; mortar; regression   analysis
     This study examines whether the maturity method is applicable to represent the strength development of high-performance concrete mixtures cured at different temperatures. Two mortar mixtures were investigated having water to cementitious solids ratios of 0.29 and 0.36. The mixtures were made with Type I cement, silica fume (10% by mass of cement), and a high-range water reducing admixture. Ten batches of mortar were prepared to make cube specimens, which were cured under water of three temperatures: 7, 23, and 40 deg C. Compression strengths were measured at ages ranging from 4 hours to 139 days. The strength-age data were analyzed using three models to determine the rate constant for strength development at each curing temperature. The models included two hyperbolic equations (linear and parabolic) and an exponential equation. The rate constant versus curing temperature relationship for each model was represented by a simple exponential equation, which was used to convert test ages to equivalent ages of curing at 23 deg C. The strength development of the various mortar batches could be described by a single equation relating relative strength to equivalent age. Thus it was concluded that the maturity method is applicable to describe strength development of the low water-cement ratio mixtures. It was also observed that the estimated long-term strength of the batches did not appear to be affected by the curing temperature. This is in direct contrast with the known behavior of conventional concrete mixtures.

47. Cheok, G. S.; Stone, W. C.; Lew, H. S.
     Partially Prestressed and Debonded Precast Concrete Beam-Column Joints.
     National Institute of Standards and Technology, Gaithersburg, MD
     U. S./Japan Joint Technical Coordinating Committee. Precast Seismic Structural Systems.
     3rd Meeting. November 1992, San Diego, CA, 1-9 pp, 1992.

     joints; scale models; tests; precast concrete; boundary conditions; beam cross sections; failure mode; displacement ductility; connection strength; energy absorption
     The experimental test results from three 1/3-scale model precast concrete beam-to-column connections is summarized. These tests are part of a multi-phased test program begin conducted at the National Institute of Standards and Technology. The objective of the test program is to develop guidelines for an economical precast beam-to-column connection for regions of high seismicity. The test specimens were interior connections designed using the Uniform Building Code [ICBO, 1985 and 1988] criteria for seismic Zones 2 and 4 as design guidelines. Partially debonded strands were employed in two of the specimens and while the third combined low strength steel with post-tensioning steel. Specimens were subjected to reversed cyclic loading according to a prescribed displacement history. Comparisons are made between the behavior of these precast specimens with previous precast and monolithic specimens which were tested earlier. The comparisons were based on connection strength, connection ductility, and energy absorption characteristics.

48. Cleary, T. G.
     Flammability Characterization With the LIFT Apparatus and the Cone Calorimeter.
     National Institute of Standards and Technology, Gaithersburg, MD
     Fire Retardant Chemicals Association. Technical and Marketing Issues Impacting the Fire
     Safety of Building and Construction and Home Furnishings Applications. Spring Conference,

1992. March 29-April 1, 1992, Orlando, FL, Technomic Publishing Co. Lancaster, PA, 99-115 pp, 1992.

> fire retardants; fire safety; construction; cone calorimeters; flammability; ignition; flame spread; heat release rate; solid materials

Two small-scale test apparatuses, the LIFT apparatus and the Cone Calorimeter provide ignitability, flame spread, and heat release rate data for combustible solid materials. Data gathered with these apparatuses can be reduced to a limited number of key flammability or fire properties for a particular material. These key properties, in conjunction with the appropriate modelling equations, characterize the time to ignition, flame spread rate, and heat release rate over the range of applicable heating conditions and surface temperatures likely in full-scale fires. These key properties may be used as input parameters in a fire model that predicts flame spread and heat release rates for certain full-scale fire scenarios.

49. Cleary, T. G.; Mulholland, G. W.; Ives, L. K.; Fletcher, R. A.; Gentry, J. W.
Ultrafine Combustion Aerosol Generator.
National Institute of Standards and Technology, Gaithersburg, MD
Maryland Univ., College Park
Aerosol Science and Technology, Vol. 16, 166-170, 1992.

> aerosol generators; combustion aerosols; particle size; size distribution; mass spectroscopy

We are able to produce a narrowly distributed combustion aerosol with a mean particle size of about 10 nm by operating a laminar diffusion burner with acetylene fuel in the nominal "presooting" condition. Number concentrations of approximately 106 particles/cm3 are obtained. The mean particle size obtained by transmission electron microscopy (TEM) and by diffusion battery (DB) is 7 nm and 10 nm, respectively. Both measurements indicate a narrow size distribution with a geometric standard deviation of less than 1.4. Laser microprobe mass spectroscopy (LAMMS) indicates that the particles are composed of phosphorous and sulfur compounds, arising from acetylene fuel impurities, in addition to carbonaceous material.

50. Cleary, T. G.; Ohlemiller, T. J.; Villa, K. M.
Influence of Ignition Source on the Flaming Fire Hazard of Upholstered Furniture.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4847; 71 p. June 1992.
Available from National Technical Information Services
PB92-205384

> upholstered furniture; ignition source; chairs; fabrics; fire statistics; fire hazard; furniture calorimeters; hazard analysis; home fires

A set of upholstered chairs constructed from five different fabric/foam combinations was subjected to a variety of ignition sources suggested by fire statistics. The sources included a cigarette, a small match-like flame, an incandescent lamp, a space heater, and a large flame source (CTB 133 equivalent gas burner). The tests were performed in a furniture calorimeter where heat release rate and species production rates were obtained. For any chair type, the time to the peak heat release rate depended on the ignition sequence, but the magnitude of the peak did not, within the scatter of the data for any given chair. HAZARD I, the fire hazard assessment method developed at NIST, was used to quantify the hazard posed by the different ignition scenarios. No deaths were predicted when a working smoke detector was present. When a detector was not present, the results from the limited number of scenarios considered confirm the importance of a low peak heat release rate and a slow rate of rise to lessen the hazard of upholstered furniture fires. No one of the ignition scenarios examined consistently yielded the greatest potential hazard for all chair types tested when ignition and sustained burning was achieved. It is recommended that the hazards of upholstered furniture for residential use be assessed on the basis of resistance to small flame and cigarette ignition combined with peak heat release rate and time to peak subsequent to ignition by a strong source such as the CTB 133 equivalent gas burner.

51. Clifton, J. R.; Pommersheim, J. M.
Methods for Predicting Remaining Life of Concrete in Structures.
National Institute of Standards and Technology, Gaithersburg, MD

Bucknell Univ., Lewisburg, PA
NISTIR 4954;   30 p. November 1992.
Available from National Technical Information Services
PB93-139030

> concretes; structures; building technology; corrosion; diffusion; service life; reinforcement; reaction controlled; remaining service life; time order

The ability to predict the remaining life of concrete structures is becoming increasingly important as the nation's infrastructure ages. Decisions on whether to repair or to demolish structures may depend on the estimated remaining life. Little attention has been given to developing methods for predicting remaining service lives, with most of the reported work dealing with corrosion of concrete reinforcement. These methods primarily involve the use of mathematical models and life-time extrapolations based on corrosion current measurements. Predicting remaining service life usually involves making some type of time extrapolation from the present state of the concrete to the end-of-life state.
The application of the time order concept in making time extrapolations is described in this report. Also, ways to determine the value of n (time order) in the time function tn of degradation rate relationships are given. Use of the time order approach is demonstrated for n = 1/2, 1, and 2. Ways to apply the approach to cyclic processes and multi-degradation processes are also discussed. Situations may be encountered in which the remaining service life of concrete can only be estimated by predicting its original life using a service-life model. Such a situation could arise where the concrete can not be inspected or samples taken, due to its inaccessibility or to potential serious hazards involved with its inspection. An approach for applying this method is discussed.

52.   Collins, B. L.; Dahir, M. S.; Madryzkowski, D.
Visibility of Exit Signs in Clear and Smoky Conditions.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of the Illuminating Engineering Society, Vol. 21, No. 1, 69-84, Winter 1992.

> exit signs; visibility; standards; luminescence

In the present study, the visibility of several types of internally it exit signs was assessed under both clear and smoky conditions. In the evaluation both photometric and psychophysical measures were taken.

53.   Collins, B. L.; Sanders, P. A.
Evaluation of the Visibility of Buoys and Topmarks.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4756;   76 p. March 1992.
Available from National Technical Information Services
PB92-172469

> buoys; topmarks; visibility; color; detection; lighting equipment; navigation aid; shape

The research literature on the visibility of colors and topmarks used to code information on buoys and other aids to navigation was reviewed. Although several studies suggest that color may be recognizable at greater distances than topmarks, it is difficult to draw conclusions about the relative effectiveness of different topmark, color, and buoy configurations because the researchers used small numbers of observers and tested different aspects of aids to navigation. Consequently, two experiments were conducted to determine the distance at which buoy topmark configurations could be correctly identified for different lighting geometries and background conditions. In experiment 1, the visibility of buoys and topmarks as separate entities was evaluated for ten different buoy configurations in simulated waterway viewing environments. Four buoys, including safe water, danger, port and starborad, were shown with and without topmarks, while two buoys, north and east, always had topmarks. Front and back lighted buoys were presented against both water and foliage, as well an in a "twilight" condition. In experiment 2 the visibility of buoys with integral topmarks was evaluated for front lighting conditions only. Analysis of the data from both experiments strongly suggests that topmarks did not increase the visibility of the buoy configurations studied. It appears that the topmark is too small to be effective beyond 0.8 km (0.5 mile) - near the limit of visual resolution. The data indicated that color is a critical clue in determining buoy type, with significant differences in buoy detectability between red and green buoys. Front lighting also increased visibility distance significantly. Even under back lighting conditions, however, the presence of a topmark did not increase buoy visibility. While it is possible that training could have improved accuracy, its effects would likely be limited to distances shorter than 0.8 km (0.5 miles).

54.   Collins, B. L.; Treado, S. J.; Ouellette, M. J.
Evaluation of Compact Fluorescent Lamp Performance at Different Ambient Temperatures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4935;   51 p. December 1992.
Available from National Technical Information Services

compact fluorescent lamp; lighting equipment; temperature; evaluation; conservation; costs

Compact fluorescent lamps are currently being used to replace incandescent lamps to aid in energy conservation in commercial and domestic lighting applications. In particular, they offer the benefits of much longer life and lower operating costs in a reasonably similar package (Bouwknegt, 1982). Some of the performance characteristics that the residential user is accustomed to may differ, however, for the newer lamp technology. Such characteristics include response to ambient thermal conditions, sensitivity to lamp position, flicker, harmonics, etc. Of particular concern is the response to ambient thermal conditions, since such lamps may be used in unconditioned spaces, such as garages, basements, barns, and similar spaces where they may be subjected to extremes in temperature, both hot and cold. While it is well known that fluorescent lamp performance is determined by the cold spot on the lamp and can be affected by the ambient temperature in the room (IESNA, 1984), the extent to which these findings, particularly for extreme in temperatures, apply to compact fluorescent lamp applications is not well understood.

55.   Cooper, L. Y.; Nelson, H. E.
'Feeling a Door' To See If Fire Is On the Other Side. Technical Note.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Technology, Vol. 25, No. 3, 251-256, August 1992.

doors; door assemblies; detection; fire fighting; fire hazards; smoke barriers; smoke transport

This paper considers door assemblies that separate a fire environment from a protected space. It analyzes three methods of "feeling a door" on the protected side that can assist in determining the existence of a direct fire threat on the other side. These methods are 1) feeling the door surface to determine whether or not it is at an elevated temperature; 2) feeling, smelling and visual inspection of the door edges to determine possible smoke flows from an adjacent fire environment; and 3) feeling the door-knob to determine whether or not it is at an elevated temperature. It is determined that a practical and effective strategy can be developed which uses all three methods to establish the existence of a fire threat without direct exposure to the fire environment. Of all methods discussed, the most reliable single indicator involves touching the base of the door-knob.

56.   Council of American Building Officials
Assessment of the Seismic Provisions of Model Building Codes.
Council of American Building Officials, Falls Church, VA
NIST-GCR-91-598;   174 p. July 1992.
Available from National Technical Information Services

building codes; earthquakes; earthquake design; Executive Order 12699; model codes; seismic design; seismic safety

The seismic provisions of four major model building codes are compared to the 1988 edition of the NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings. The 1992 BOCA National, 1992 SBCCI Standard, and 1991 ICBO Uniform Building Codes are found to be substantially equivalent to the NEHRP Recommended Provisions. The CABO 1 and 2 Family Dwelling Code is found to be not equivalent. Crosswalks indicate comparable NEHRP section numbers for each of the compared codes. This report was prepared to assist the Interagency Committee on Seismic Safety in Construction (ICSSC) and Federal agencies in identifying codes appropriate for use in implementing Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction". The ICSSC recommends the use of codes and standards that are substantially equivalent to the NEHRP Recommended Provisions.

57.   Danner, W. F.; Yang, Y.
STEP (Standard for the Exchange of Product Model Data) Development Methods: Specification of Semantics for Information Sharing.
National Institute of Standards and Technology, Gaithersburg, MD
Product Data Integration Technology, Long Beach, CA

NISTIR 4915;   24 p. September 1992.
Available from National Technical Information Services
PB93-113686

> architecture; specifications; application interpretation; product data; product data architecture; product information sharing; product data integration; product data modelling; product data specification; resource integration

This document describes the information sharing requirements and approaches used to fulfill those requirements in the development of standardized data constructs for STEP (Standard for the Exchange of Product Model Data). It also describes the architecture used to conceptually organize the data constructs, and the information sharing architecture in which the standardized constructs are used.

58.   Davis, W. D.
LAVENT: Link-Activated VENTs.
National Institute of Standards and Technology, Gaithersburg, MD
SFPE Bulletin, 10-12, March/April 1992.

> computer models; fire models; sprinklers; compartments

Computer fire modeling at the National Institute of Standards and Technology (NIST) began in 1976 when the Illinois Institute of Technology Research Institute developed a fire model called RFIRES. Subsequently the Harvard Fire Model, now known as FIRST, was developed at Harvard University. Computer modeling initially required main frame computers, severely restricting the use of these models by the fire community.

59.   Day, A. R.; Snyder, K. A.; Garboczi, E. J.; Thorpe, M. F.
Elastic Moduli of a Sheet Containing Circular Holes.
Marquette Univ., Milwaukee, WI
National Institute of Standards and Technology, Gaithersburg, MD
Michigan State Univ., East Lansing, MI
Journal of the Mechanics and Physics of Solids, Vol. 40, No. 5, 1031-1051, 1992.

> circular holes; elastic moduli; digital-image-based model; numerical method; experiments

We apply computer simulation techniques to obtain the elastic moduli of a matrix containing circular holes. As the area fraction of holes increases, the Young's modulus of the composite decreases from E_o until it eventually vanishes at the percolation threshold. We study three distinct geometries: (a) periodically centered circular holes on a honeycomb lattice, (b) periodically centered circular holes on a triangular lattice, and (c) randomly centered circular holes. All three cases have the same dilute limit that can be calculated exactly. By examining the narrow necks between adjacent circles, we have calculated the critical behavior for the regular cases and obtain critical exponents of 1/2 or 3/2, depending on the local breakdown mode at the necks. For (c) we compare our results with an effective-medium theory, which predicts that the Poisson's ratio tends to 1/3 as the percolation threshold is approached, independent of its value in the pure system. Our results are also compared with recent experimental results. Based on this work, we propose that the relative Young's modulus E/E_o of a two-dimensional sheet containing circular holes, overlapping or not, is the same for all materials, independent of the Poisson's ratio v_o, for any prescribed geometry.

60.   Dietenberger, M. A.
Modifications to Furniture Fire Model for Hazard System. Final Report. July 30, 1990-July 31, 1991.
Dayton Univ., OH
NIST-GCR-92-601;   126 p. January 1992.
Available from National Technical Information Services
PB92-148295

> fire models; algorithms; cushions; fire retardant materials; fire spread; foam (materials); ignition; upholstered furniture

This final technical report describes the work accomplished during the period from 31 July 1990 through 31 July 1991 by the University of Dayton Research Institute under grant 60NANBOD1051 for the National Institute of Standards and Technology. Modifications to the furniture fire model for inclusion in the HAZARD system required three major tasks: (1) comparison of the FAST/FFM predictions with several full-scale burns measured in the furniture calorimeters, (2) development of an algorithm for personal computers to calibrate ignition and flame spread parameters, and (3) conversion of FF to a Flame Spread Model (FSM) for a single panel. The code was implemented on the PC for use with CFAST. The application problems are compartmentation, structural fire resistance, ignitibility of a secondary combustible item and room flashover studies.

61.   Dikkers, R. D.
        Development of Seismic Design and Construction Standards for Lifelines.
        National Institute of Standards and Technology, Gaithersburg, MD
        NIST SP 840;   468 p. August 1992.
        U. S./Japan Workshop on Earthquake Disaster Prevention for Lifeline Systems, 4th
        Proceedings. August 19-21, 1991, NIST SP 840, Los Angeles, CA, Equchi, R. T., Editor,
        193-197 pp, 1992.
        Available from Government Printing Office

                lifeline facilities; standards; earthquakes

        Section 8(b) of the National Earthquake Hazards Reduction Program Reauthorization Act, which was approved on November 16, 1990, requires the Federal Emergency Management Agency (FEMA), in consultation with the National Institute of Standards and Technology (NIST), to submit to the U. S. Congress, not later than June 30, 1992, a plan for developing and adopting, in consultation with appropriate private sector organizations, design and construction standards for lifelines. This paper discusses the process, participants, and schedule being utilized to prepare the lifelines standards development plan. Lifeline systems being addressed are electrical power, gas and liquid fuel, telecommunications, transportation, and water and sewer. The plan will include the following information for the various lifeline systems: seismic vulnerability; current design and construction practices and standards; available knowledge to improve existing practices; recommended standards to be developed for new and existing construction; and recommended research to fill identified knowledge gaps.

62.   Dols, W. S.; Persily, A. K.
        Study of Ventilation Measurement in an Office Building.
        National Institute of Standards and Technology, Gaithersburg, MD
        NISTIR 4905;   42 p. October 1992.
        Available from National Technical Information Services

                office buildings; airflow; building performance; carbon dioxide; commercial buildings; indoor air quality;
                measurements; tracer gas; ventilation

        The National Institute of Standards and Technology has conducted a study of ventilation and ventilation measurement techniques in the Bonneville Power Administration (BPA) Building in Portland, Oregon. The project involved the comparison of outdoor air ventilation measurement techniques for relative accuracies and an examination of changes in building ventilation rates over time. The following measurement techniques were compared: tracer gas decay measurements of whole building air change rates, the determination of air change rates based on peak carbon dioxide (CO_2) concentrations, the determination of percent outdoor air intake using tacer gas (sulfur hexafluoride and occupant-generated CO_2), and direct airflow rate measurements within the air handling system. In addition, air change rate measurements made with an automated tracer gas decay system approximately three years apart were compared. The major findings of the study are as follows. Airflow rates were measured in the air handling system ductwork using pitot tube, hot-wire anemometer, and vane anemometer traverses, and good agreement was obtained between the different techniques. While accurate determinations of percent outdoor air intake were achieved using tracer gas techniques, the use of CO_2 detector tubes yielded unreliable results. Reliable determinations of ventilation rates per person were made based on SF_6 decay and direct airflow rate measurements but the use of peak CO_2 concentrations led to inaccuracies, i.e., the overprediction of ventilation rates by as much as 100%. The measured values of the whole building air change rates, and their dependence on outdoor air temperature, did not change significantly over a three year period. The minimum air change rates were above the building design value and ASHRAE Standard 62-1981, the standard on which the design was based, but the minimum rates were below the minimum recommendation given in Standard 62-1989. The whole building air change rate under minimum outdoor air intake conditions was determined to

be twice the outdoor air intake rate provided by the minimum outdoor air intake fans. The additional air change under minimum outdoor air intake conditions was due primarily to leakage through the main outdoor air intake dampers.

63.   Domanski, P.A.; Didion, D. A.; Doyle, J. P.
Evaluation of Suction Line-Liquid Line Heat Exchange in the Refrigeration Cycle.
National Institute of Standards and Technology, Gaithersburg, MD
Giant Food, Inc., Washington, DC
International Refrigeration Conference. July 14-17, 1992, West Lafayette, IN, 1-9 pp, 1992.

refrigeration; heat transfer; evaluation; installations; thermodynamic properties

The paper presents a theoretical evaluation of the performance effects resulting from the installation of a liquid line/suction line heat exchanger (llsl-hx). It examines cycle the parameters and refrigerant thermodynamic properties that determine whether the installation results in improvement of COP and volumetric capacity. The study showed that the benefit of application of the llsl-hx depends on a combination of operating conditions and fluid properties - heat capacity, latent heat, and coefficient of thermal expansion - with heat capacity being the most influential property. Fluids that perform well in the basic cycle are marginally affected by the llsl-hx, and the impact on the Coefficient of Performance and volumetric capacity may be either positive or negative. Fluids performing poorly in the basic cycle benefit from the llsl-hx installation through increase of the Coefficient of Performance and volumetric capacity.

64.   Dougherty, B. P.; Thomas, W. C.
Thermophysical Property Measurements Using an Encapsulated Bead Thermistor: Applications to Liquids and Insulation Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Virginia Polytechnic Institute and State Univ., Blacksburg
Journal of Solar Energy Engineering, Vol. 114, 23-31, February 1992.

encapulated bead thermistor; thermal conductivity; thermal diffusivity; insulating materials; thermophysical properties; probes

A technique for simultaneously measuring thermal conductivity and thermal diffusivity was evaluated for applications with insulation materials and liquids. The thermophysical properties are determined from a single, transient measurement. The measurement apparatus employs an encapsulated bead thermistor as the sensing probe. The results from using a glass-encapsulated and a teflon-encapsulated bead thermistor are described.

65.   El-Borgi, S.; Stone, W. C.; White, R. N.; Gergely, P.
Analytical Study on Seismic Behavior of Lightly Reinforced Concrete Frame Buildings.
Cornell Univ., Ithaca, NY
Report 3;   186 p. September 15, 1992.

reinforced concretes; structures; frames; analytical models; inelastic dynamic analysis; dynamic loading; parameters; frame structures; inelastic seismic analysis; beam column section

There are many thousands of existing multi-story Reinforced Concrete (RC) frame structures that were designed with little or no account for lateral forces. Attention has been focused on frame structures designed and built during the period of 1940 to 1970. It is necessary to evaluate the lateral load resistance of these structures because the amount of reinforcing and the reinforcing details used are in sharp contrast to those now used in modern seismic design. Improved evaluation techniques and retrofit methodologies are needed for these "Lightly Reinforced Concrete" (LRC) structures. A joint research program between NIST and Cornell University was initiated in early Spring 1991 with the primary objective of developing practical engineering guidelines for improving the seismic performance of LRC frame structures. To this end, an analytical study was undertaken at Cornell University to gain a better understanding on performance of these structures in a seismic loading environment. This was done by improving existing analytical tools and then using the improved analytical approaches in analyzing a number of typical buildings. This report, which is the last of three to be provided to NIST under the current contract, summarizes the findings of this analytical investigation. The required improvements in analytical capabilities are based primarily on experimental results from a parallel research program at Cornell University on full-scale joint regions of lightly reinforced concrete structures. The research (under the sponsorship of the National Center for Earthquake Engineering Research) focuses on studying the effects of the critical parameters influencing (a) deterioration of load carrying capacity, (b) degradation of stiffness, (c) ductility, and (d) energy dissipation. The present study consisted mainly of developing a smooth hysteretic model that represents accurately the physically

non-conservative behavior of RC elements under reversed loading. The model can simulate effectively stiffness degradation, strength deterioration, unsymmetric hysteresis, and pinching effects. A System Identification method was developed to calibrate the hysteretic model parameters based on available experimental data. The model was implemented in an existing dynamic analysis program. With an improved version of this program and with a rational selection of the hysteretic parameters, two typical LRC frame structures were evaluated: an East-Coast 3-story, 3-bay structure designed for gravity loads alone, and a West-Coast 10-story, 3-bay building designed primarily for gravity loads with little attention to lateral forces. Both structures were detailed according to the 1950's and 1960's U. S. practice. Nine earthquake records were used in studying the seismic performance of these buildings, corresponding to different Peak Ground accelerations (PGA's) of Nahanni, Taft and El Centro earthquakes. The two LRC structures exhibited a somewhat different behavior under the same earthquake loadings. The 3-story building became relatively more flexible than the 10-story, resulting in a higher reduction in the seismic demand. This flexibility was caused mainly by two factors: (1) partial pullout mechanism of discontinuous positive beam reinforcement from joint panels; and (2) yielding of columns. Larger drift levels occurred in the 3-story structure. The flexural response of the 10-story building was generally less inelastic than the 3-story. Unlike the 3-story structure, shear failure of the 10-story interior columns was imminent under Taft and El centro with a PGA of 0.35g.

66. Equchi, R. T, Editor
U. S./Japan Workshop on Earthquake Disaster Prevention for Lifeline Systems, 4th
Proceedings. August 19-21, 1991, NIST SP 840, Los Angeles, CA, Equchi, R. T., Editor,
1992.
Dames and Moore, Los Angeles, CA
NIST SP 840;   468 p. August 1992.
Available from Government Printing Office
Available from the National Technical Information Service
PB93-118115

> lifeline facilities; bridges; dynamic response and analysis; earthquake disaster prevention; pipelines; repair and rehabilitation; seismic safety; tunnels; water; sewer

These proceedings document the results of the Fourth U. S.-Japan Workshop on Earthquake Disaster Prevention for Lifeline Systems held on August 19-21, 1992, in Los Angeles, California. The theme of the workshop focused on "Future Directions for Research, Application, Design of Lifeline Stems." Technical topics discussed include: effects of soils on lifeline components; seismic design and retrofit of lifeline systems; dynamic response and analysis of lifeline systems; repair and rehabilitation of lifeline systems; system reliability methods for lifeline systems; post-earthquake damage detection procedures; socioeconomic and environmental impact of lifeline system failure; and emergency and disaster response management of lifeline systems. Thirty papers were presented in two days of plenary sessions; 16 papers from Japan and 14 papers from the U. S.

67. Evans, D. D.
Suppression Research: Strategies.
National Institute of Standards and Technology, Gaithersburg, MD
Swedish Fire Research Board and National Institute of Standards and Technology. Fire
Suppression Research, 1st International Conference. May 5-8, 1992, Stockholm, Sweden,
Sjolin, V.; Evans, D. D.; Jason, N. H., Editors, 21-35 pp, 1992.

> fire suppression; fire detection; computer models; computation; experiments; dry powders; equations; crib burning

Millions of unwanted fires occur each year. More effective fire suppression is a means to minimizing property damage and life loss due to fire. The Damkohler number, which is the ratio of the characteristic time for flow or diffusion of reactants to the time required for reaction, is the basis for a fire extinction criterion that may provide insight for many fire suppression situations. A correlation of wood crib fire extinction data is used to show the predictive capabilities that can be developed from experimental results alone, even without complete and general understanding of the fire suppression phenomena. The use of computer field modeling techniques is discussed as a means to generate insight into the complex physical interactions that occur during fire suppression in an enclosure.

68.   Evans, D. D.; Walton, W. D.; Baum, H. R.; Notarianni, K. A.; Lawson, J. R.; Tang, H. C.;
        Keydel, K. R.; Rehm, R. G.; Madrzykowski, D.; Zile, R. H.; Koseki, H.; Tennyson, E. J.
        In-Situ Burning of Oil Spill: Mesoscale Experiments.
        National Institute of Standards and Technology, Gaithersburg, MD
        Fire Research Institute, Tokyo, Japan
        Minerals Management Service, Herndon, VA
        Environment Canada. Arctic and Marine Oilspill Program Technical Seminar, 15th. June
        10-12, 1992, Edmonton, Canada, Environment Canada, Ottawa, Ontario, 593-657 pp, 1992.
                oil spills; in situ combustion; experiments; crude oil; salt water; burning rate; smoke emissions; regression rate;
                heat of combustion; configurations; instruments; smoke yield; particle size distribution; mathematical models
        In 1991 a series of 14 mesoscale fire experiments were performed to measure the burning characteristics of crude oil on
        salt water. These oil burns in a pan ranged in size from 6 m square to 15 m square. Results of the measurements for
        burning rate and smoke emissions are compared to those from previous smaller scale burns conducted both in the U. S.
        and in Japan. The burning rate as indicated by the regression rate of the oil surface was found to be 0.055 + 0.01 mm/s
        for pan fires with effective diameters greater than 7 m. Smoke particulate yields from fires greater than 2 m in diameter
        were found to be approximately 0.13 of the oil burned on a mass basis. Predictions of smoke plume trajectory and
        particulate deposition at ground level from the Large Eddy Simulation (LES) model developed as part of this research
        effort were found to be different from those predicted by the EPA approved SCREEN model. LES is a steady-state
        three-dimensional calculation of smoke plume trajectory and smoke particulate deposition based on a mixed finite
        difference and Lagrangian particle tracking method.

69.   Evans, D. D.; Walton, W. D.; Notarianni, K. A.; Baum, H. R.; Tennyson, E. J.
        Burning of Large Oil Spills.
        National Institute of Standards and Technology, Gaithersburg, MD
        Minerals Management Service, Reston, VA
        Society of Fire Protection Engineers. Large Fires: Causes and Consequences. Extended
        Abstracts. SFPE Engineering Seminars. November 16-18, 1992, Dallas, TX. Society of Fire
        Protection Engineers, Boston, MA, 34-39 pp, 1992.
                oil spills; crude oil; water; experiments; burning rate; smoke yield
        Laboratory and mesoscale pool fire experiments with effective diameters from 0.4 to 17 m were conducted to obtain
        relevant data on the characteristics of burning crude oil on water. These experiments showed that the burning rate of
        the larger diameter fires in terms of the surface regression rate was 0.055 +/- 0.01 mm/s. The large crude oil pool fires
        emitted approximately 13 percent of the fuel burned as smoke particulate. Calculations of the smoke plume trajectory
        and smoke particulate settling showed that for a large pool fire that smoke deposition occurs over a narrow band
        stretching for over 100 km from the source.

70.   Fanney, A. H.; Dougherty, B. P.
        Performance of a Residential Desuperheater.
        National Institute of Standards and Technology, Gaithersburg, MD
        ASHRAE Transactions, Vol. 98, No. 1, [pages unknown], January 1992.
        American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE).
        Winter Annual Meeting. January 29, 1992, 3588, Anaheim, CA, 1992.
                heat pumps; heating; water; residential buildings; desuperheater; instruments
        The performance of a residential earth-coupled heat pump having an integral desuperheating water-heating circuit is
        presented. The system, which includes a 50-gallon electric water heater, is located in a home in Gaithersburg, Maryland.
        During a 24-month monitoring period, the desuperheater contributed 27% of the total energy supplied for heating water.
        On a monthly basis, the desuperheater's contribution varied from less than 1% to 55%. Simple payback for the
        desuperheater is projected to occur by the end of the fourth year of operation. For a few selected days during the
        monitoring period, data were recorded every minute to gain insight into how the desuperheater and resistive elements
        interact in recovering the water heater. In general, the desuperheater contributed most to heating the lower portion of
        the tank from the setpoint of the lower thermostat, 110 deg F, to temperatures occasionally approaching 140 deg F.

71.   Fanney, A. H.; Dougherty, B. P.
Thermal Performance of Residential Electric Water Heaters Subjected to Various Off-Peak
Schedules.
National Institute of Standards and Technology, Gaithersburg, MD
Solar Engineering, Vol. 2, 1221-1230, 1992.
American Society of Mechanical Engineers; Japan Solar Energy Society; and Korean Solar
Energy Society. International Solar Energy Conference, 1992. April 5-9, 1992, Maui, HI,
Am. Soc. of Mechanical Engineers, New York, NY, Stine, W.; Kreider, J.; Watanabe, K.,
Editors, 1992.

electric heaters; water heaters; tests; computer models; thermal efficiency

A number of electric utilities use residential water heaters for reducing electrical demand. A water heater used in this
manner is typically called an off-peak water heater because resistive heating is unrestricted during utility off-peak periods.
During on-peak periods, by comparison, the utility seeks to limit and delay resistive water heating. Laboratory tests,
where the off-peak period and hot water draw schedule were varied, were conducted on two residential storage water
heaters. A computer model of an electric water heater was developed and validated. The laboratory tests and the model
were used to quantify the effect that various off-peak and hot water draw schedules have on water heater thermal
efficiency. Thermal efficiency was found to vary up to 7% for water heaters which meet the 1991 minimum efficiency
standards as specified within the National Appliance Energy Conservation Act. The energy factor, as measured using the
Department of Energy Test Procedure for Water Heaters, was found to be independent of the off-peak schedule because
of a "normalizing" that occurs as part of the calculation procedure.

72.   Fleischmann, C. M.; Pagni, P. J.; Williamson, R. B.
Backdraft Experiments.
California Univ., Berkeley
21 p. 1992.

experiments; computer programs; simulation

Backdraft is defined as a rapid deflagration following the introduction of oxygen into a compartment filled with
accumulated excess pyrolyzates. A scenario describing the physical and chemical fundamentals underlying backdraft
phenomena is presented. A half-scale apparatus, designed to avoid dangerous over-pressures, is used to obtain data
from backdraft experiments. A gas burner supplies a 150 kW natural gas fire in a 1.2 m high, 1.2 m wide, 2.4 m long
compartment with a small, 2.5 cm high 30 cm wide, vent at floor level. Significant excess pyrolyzates accumulate in 180
sec, when a hatch covering a 0.4 m high 1.2 m wide vent, centered on a short wall, is opened, simulating a window
breaking due to thermal stresses. The propagation across the compartment of the cold density driven flow, which now
enters through the vent, is called a gravity current. The gravity current carries a flammable mixed layer, formed in the
shear layer at the interface with the hot fuel-rich layer, to a spark located by the burner on the opposite wall. The rapid
deflagration which then results is a backdraft. The average total travel time of the gravity current and the deflagration,
in and out of the compartment respectively, is 5.4 + 0.9 sec. The FIRST compartment fire model is used to calculate
conditions in the compartment prior to the backdraft The hypothesized scenario is confirmed. Future work will provide
more quantitative species and flow data and will extend this study to more common firefuels.

73.   Forney, G. P.; Davis, W. D.
Analyzing Strategies for Eliminating Flame Blow-down Occurring in the Navy's 19F4 Fire
Fighting Trainer.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4825;   56 p. May 1992.
Available from National Technical Information Services
PB92-191253

fluid dynamics; fire models; zone models; fire fighting; experiments; fans; burners; simulation

The purpose of this report is to document a series of numerical experiments performed to analyze strategies for
eliminating flame blow-down occurring in the Navy's 19F4 fire fighting training. The first strategy involves the use of a
fence in the way fences are used as tennis court wind breaks. The second strategy involves the use of fans to pressurize

the space below the propane burners. Numerical simulations were performed for various fence heights, fence distances from the platform and fan volume flow rates. These tests confirmed that flame blow-down occurs when no action is take to prevent it and predicted that blow-down will be reduced with the use of a fence and a fan.

74.   Forney, G. P.; Davis, W. D.; Klote, J. H.
Simulating the Effect of Beamed Ceilings on Smoke Flow. Part 1. Comparison of Numerical and Experimental Results.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4994;   24 p. December 1992.
Available from National Technical Information Services
PB93-152056

ceilings; smoke flow; detector response; experiments; simulation; beams

The flow of smoke under beamed ceilings is simulated using a field model. This work was performed in order to confirm that fire detector response can be evaluated using computational data obtained from numerical simulations as well as laboratory data obtained from experiments. The field model is verified for this application by showing that its temperature predictions match experimental results obtained by Heskestad and Delichatsios. Line plots are presented which show that the numerical and experimental temperature measurements are in good agreement. Contour plots are also presented that show the temperature distribution in the channels formed by the ceiling beams. Finally some preliminary results involving the effect of beam depth on smoke flow are presented.

75.   Forney, G. P.; Moss, W. F.
Analyzing and Exploiting Numerical Characteristics of Zone Fire Models.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4763;   44 p. March 1992.
Available from National Technical Information Services
PB92-172790

zone models; fire models; computer models; numerical analysis

In order to design robust and stable zone fire modeling algorithms, the numerical properties of computer arithmetic and modeling differential equations must be understood. This report examines some of these properties and provides tools for their analysis. Many sets of different equations for zone fire modeling can be derived using the conservation of mass and energy. A comparison between various possible formulations is made in terms of numerical properties. One property that many formulations possess is the presence of multiple time scales. Pressures equilibrate much faster than other quantities such as density and temperature. Numerically, this property is known as stiffness. Stiffness, in the context of fire modeling, and numerical methods for handling it are discussed.

76.   Frey, M.; Simiu, E.
Equivalence Between Motions With Noise-Induced Jumps and Chaos With Small Horeshoes.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers (ASCE)/EM Div. Engineering Mechanics Proceedings.
May 24-27, 1992, College Station, TX, 660-663 pp, 1992.

noise (sound); oscillators; motion; jumps; chaos; horseshoes

For certain sets of parameters multi-stable oscillators excited by noise can exhibit irregular jumps. We consider one-degree-of-freedom near-integrable multi-stable systems whose unperturbed flows have homoclinic/heteroclinic orbits. For such systems we show that certain motions with noise-induced jumps are in fact chaotic motions with traveling Smale horseshoe sequences. Consequences of our result are that noise can, by itself, induce such chaotic motions. In the presence of periodic or quasiperiodic excitation, noise cannot suppress chaotic motion that might otherwise occur; rather, its effect is to broaden the windows of chaotic behavior.

77.   Frey, M.; Simiu, E.
Noise-Induced Chaos and Phase Space Flux: A Sample-Theoretic Study.
National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 4791;   36 p. March 1992.
Available from National Technical Information Services

noise (sound); chaos; space flux; global perturbation methods; homoclinic orbit; asymptotic mean stationarity; sample-theoretic method

We study the effect of additive noise on near-integrable second-order dynmaical systems whose unperturbed flows have homoxlinic or heteroclinic orbits. The noise is represented by a type of Shinozuka stochastic process capable of arbitrarily closely approximating Gaussian noise with any specified spectrum. We derive a formula for the flux factor applicable for any asymptotic mean stationary excitation. This derivation shows that, to first order, the effect of the external excitation on the system is mediated by a linear filter associated with the system homocolinic or heteroclinic orbit. It also shows that the stationary mean distribution of the filtered excitation determines the average phase spac flux. This is true for both random and nonrandom excitations and indicates that, for the dynamical systems considered here, these two classes of excitation play substantially equivalent roles in the promotion of chaos.

78.   Frohnsdorff, G.; Clifton, J. R.
Portland Cements and Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
Engineered Materials Handbook. Volume 4. Ceramics and Glasses, ASM International, Materials Park, OH, 918-924 p., 1992.

portland cement; concretes; ceramics; chemistry; tests; standards

79.   Garboczi, E. J.; Bentz, D. P.
Computer Simulation of the Diffusivity of Cement-Based Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Materials Science, Vol. 27, 2083-2092, 1992.

cements; simulation; diffusivity; microstructural model; percolation properties; computation; pore structure

A digital image-based model of the microstructure of cement paste, coupled with exact transport algorithms, is used to study the diffusivity of Portland cement paste. The principal variables considered are water:cement ratio, degree of cement hydration and capillary porosity. Computational methods are described and diffusivity results are presented, which are found to agree with the available experimental measurements within experimental error. Model cement pastes prepared with different water:cement ratios, and having different degrees of hydration, are found to have diffusivities that lie on a single master curve when plotted as a function of capillary porosity. Concepts from percolation theory are used to explain quantitatively the dependence of diffusivity on capillary porosity. The effect of silica fume addition on diffusivity is also examined.

80.   Gottuk, D. T.
Generation of Carbon Monoxide in Compartment Fires. Annual Report. September 1991-September 1, 1992.
Virginia Polytechnic Institute and State Univ., Blacksburg, VA
NIST-GCR-92-619;   265 p. December 1992.
Available from National Technical Information Services
PB93-146702

carbon monoxide; compartment fires; fire plumes; flexible foams; hexanes; polyurethane foams; polymethylmethacrylate; solid fuels; toxic gases; wood

A 2.23 test compartment was used to investigate the burning of four fuels (hexane, PMMA, spruce, and flexible polyurethane foam) in compartment fires. Empirical correlations between the upper-layer yield of major species and the plume equivalence ratio were shown to exist. The results reveal that the production of CO is primarily dependent on the compartment flow dynamics and upper layer temperature. A chemical kinetic analysis indicated that increased compartment temperature affects upper-layer species yields in two ways: 1) the generation of species in the plume is changed, and 2) oxidation of post-flame gases in the layer is affected. The correlations developed in the compartment fires were qualitatively similar to those developed by Beyler for simplified upper-layer environments. The species yields downstream of hexane compartment fires were investigated and compared to upper-layer yields. Results showed that downstream CO yields can be correlated to the plume equivalence ratio when taking into account the occurrences of external burning.

81. Graves, R. S.; McElroy, D. L.; Miller, R. G.; Yarbrough, D. W.; Zarr, R. R.
Comparison of Heat-Flow-Meter Tests From Four Laboratories.
Oak Ridge National Lab., TN
Jim Walter Research Corp., St. Petersburg, FL
Tennessee Technological Univ., Cookeville, TN
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Thermal Insulation, Vol. 15, 354-357, April 1992.

> measuring instruments; heat transmission; thermal conductivity; equipment; laboratories; equations

A recent comparison of apparent thermal conductivities, measured at the Oak Ridge National Laboratory (ORNL), Jim Walter Research Corp. (JWRC), Tennessee Technological University (TTU), and the National Institute of Standards and Technology (NIST) has been discussed in an ORNL Report. The four laboratories used equipment built and operated in accordance with ASTM C 518, and used different calibration materials and procedures.

82. Groner, N. E.; Levin, B. M.
Human Factors Considerations in the Potential for Using Elevators in Building Emergency Evacuation Plans.
George Mason Univ., Fairfax, VA
NIST-GCR-92-615; 61 p. August 1992.
Available from National Technical Information Services
PB92-238641

> human factors engineering; elevators; evacuation; fire protection; handicapped; high rise
> buildings; human behavior; office buildings.

If elevators could be safely used in fire emergencies, the safety of building   occupants with mobility limitations could be greatly enhanced and the time for all occupants to evacuate might be reduced.   This report covers a study of human factors considerations related to the possible use of elevators for evacuations in fire   emergencies. It covers the selection of the fundamental approach to organizing elevator evacuations for specific
buildings; the coordination and direction of the evacuation; the decision-making, information and communication needs to permit a coordinated evacuation; and the documentation, manning and training requirements to permit a proper implementation of the fire emergency plan.

83. Gross, J. G.
Growing Significance of CIB.
National Institute of Standards and Technology, Gaithersburg, MD
CIB Information, No. 6, 1, 1992.

> research facilities; construction; building management

Serving one term on the CIB Board and its Program Committee and now beginning a second term on the Board and on the Administrative Committee, provides insight to consider the value of CIB from a non-European perspective. During this short period of time, much has happened which affects all sectors of the world building community. The global competition to supply construction products and services has become much more intense. At the same time, the demand for higher quality in construction is heard worldwide. These factors impose upon CIB obligations and opportunities to improve the build environment.

84. Gross, J. L.; Kunnath, S. K.
Application of Inelastic Damage Analysis to Double-Deck Highway Structures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4857; 83 p. August 1992.
Available from National Technical Information Services
PB92-226323

> highways; structures; computer models; damage; earthquakes; reinforced concretes; case histories

The Loma Prieta earthquake of October 17, 1989, caused extensive damage to many highway structures and particularly to double-deck structures. The most notable was the collapse of the Cypress Viaduct (Interstate 880). A study was undertaken by NIST to identify, using computer-based analysis methods, causes of structural failure of elevated highway

structures resulting from the Loma Prieta earthquake and thereby reveal the potential for damage or collapse of similar structures nationwide. The IDARC analysis program, developed at the University of Buffalo, was used in the inelastic seismic analysis. Features of the program and enhancements incorporated to model the Cypress Viaduct structure are described. To accurately determine beam and column moment-curvature relationships, separate computer analyses were conducted. In addition, a smeared-crack approach finite element analysis was employed to determine the lateral load-deformation relationship of the pedestal regions. The model of the Cypress Viaduct was subjected to the Oakland Outer Harbor Wharf ground acceleration record in the plane of the bent. The analytical model was calibrated using static lateral load tests, ambient and forced vibration tests, and observed performance. Results of time-history analyses, which include a prediction of member damage, indicate that collapse was initiated by a shear failure of the pedestal regions as concluded by the Governor's Board of Inquiry. The analytical and modeling procedures reported herein may be used to facilitate comparison and selection of effective approaches to seismic strengthening.

85. Grosshandler, W. L.; Jackson, M.
Acoustic Emission of Structural Materials Exposed to Open Flames.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4984;   26 p. December 1992.
Available from National Technical Information Services
PB93-138980

fire detection; acoustic properties; acoustic sensors; material properties

The use of acoustic emission (AE) as an early indicator of a hidden structural fire has been investigated and found to be a viable, but undeveloped, concept. Piezoelectric transducers have been mounted directly on 0.5 m long, simply support beams of different structural materials (aluminum, gypsum board, wood and plastic), and have been used to record ultrasonic events resulting from a small flame placed under the beam. The number of AE events in a minute and the cumulative energy released during the heating cycle provide a good measure of the overheated state of some of these materials even before a temperature increase is indicated. The measured signals arises in energy and number with the type of material, the thickness of the specimen and heat flux. Wood was particularly susceptible to acoustic emission, producing more than 1000 events per minute in the solid fir board and 30/min in the 13 mm thick plywood when the flame exceeded 1.0 kW. The gypsum board produced 16 events in a minute. The aluminum plate did not respond above the background level (0.3 events/minute) even though it reached the highest temperature. The differences in cumulative energy were equally striking, with the plywood being four times more energetic than the gypsum board even though the heating period for the wood was half as long, and 30 times more energetic than the aluminum. The critical issues which remain to be investigated before this technique can be adapted to practical fire detection applications are mentioned.

86. H. J. Degenkolb Associates, Engineers; Rutherford and Chekene
Proceedings: ICSSC Issues Workshop. Development of Seismic Evaluation and
Rehabilitation Standards for Federally Owned and Leased Buildings. September 16-17, 1992.
Denver, Colorado.
H. J. Degenkolb Associates, Engineers
Rutherford and Chekene
NIST-GCR-92-617;   48 p. October 6, 1992.
Available from National Technical Information Services

building technology; earthquakes; evaluation; existing building; rehabilitation; seismic; seismic safety; strengthening; structures

The Interagency Committee on Seismic Safety in Construction (ICSSC) hosted an Issues Workshop in Denver, Colorado on September 16-17, 1992, to develop consensus resolution of issues affecting the drafting of seismic evaluation and rehabilitation standards for Federally owned and leased buildings. The development of the standards was mandated by Congress in Public Law 101-614. All potentially affected Federal agencies were invited to participate in the workshop. Based on the outcome of the workshop, it is anticipated that the standard (referred to herein as the Guidelines) will have the following features. The overall goal of the program described in the Guidelines will be to reach seismic life-safety in all Federally owned and leased buildings in 35 years. Guidance for achieving non-mandatory higher performance goals will be included. The program will include screening, evaluation, prioritization and additional triggers, and strengthening. Existing voluntary technical standards will be incorporated by reference to the greatest degree possible. Leased areas greater than 50% of a building or greater than 10,000 square feet in area will be included in the overall program, but with flexibility to account for areas where complying space is unavailable. Incremental strengthening that improves the

performance of the building will be allowed, but program milestones and timeliness must still be met. The Guidelines
will   be a required minimum standard that will be updated by the ISCCS every 3-5 years.

87.   Hubbard, J. B.; Nguyen, T.; Bentz, D. P.
       Model of Defect-Mediated Transport Through Amorphous Membranes.
       National Institute of Standards and Technology, Gaithersburg, MD
       Journal of Chemical Physics, Vol. 96, No. 4, 3177-3182, February 1992.

           membranes; algorithms; pore-length distribution; random-pore membranes
       We introduce a class of membrane diffusion models which consists of an impermeable slab punctured by transmembrane
       pores which are constructed by continuous random-walk algorithms. These formally infinite tortuosity models closely
       resemble low tortuosity models in their steady-state flux and total transient uptake. The sharpest contrast
       between random and homogeneous membranes is in the stretched exponential (subdiffusive) decay [equation] of the
       transient diffusive flux for the random-pore models vs simple exponential decay [equations] for homogeneous membranes.

88.   Jaluria, Y.; Kapoor, K.
       Wall and Corner Flows Driven by a Ceiling Jet in an Enclosure Fire.
       Rutgers Univ., New Brunswick, NJ
       Combustion Science and Technology, Vol. 86, 311-326, 1992.

           enclosures; walls; corners; ceiling jets
       This paper presents the results from an experimental simulation of the wall and corner flows generated by a fire-plume
       driven ceiling jet in a compartment fire. An experimental arrangement is employed to determine the transport processes
       resulting from these flows in typical full-scale fires in rooms. Of particular interest were the flow and heat transfer
       in the corner, the heat transfer rate to the wall and the ceiling, the downward penetration distance of the wall flow and
       the entrainment into the flow. The results obtained are presented in terms of dimensionless variables in order to simulate
       the conditions for a wide range of fires. The chosen range of the governing parameters corresponds to the values
       encountered in typical room and enclosure fires. Some results are also presented on a jet impinging at an inclination,
       other than normal, with the wall to simulate the radial spread of the ceiling jet in an actual fire. It is found that the
       ceiling-jet-driven wall and corner flows are very important in an accurate mathematical modeling of enclosure fires. The
       results are also applied to a typical room fire in order to determine the relative importance of these effects.

89.   Janssens, M.; Parker, W. J.
       Oxygen Consumption Calorimetry.
       National Forest Products Assoc., Washington, DC
       National Institute of Standards and Technology, Gaithersburg, MD
       Heat Release in Fires, Chapter 3, Elsevier Applied Science, NY, Babrauskas, V.; Grayson,
       S. J., Editors, 31-59 pp, 1992.

           heat release rate; fire protection engineering; oxygen consumption; calorimetry; flow rate; equations; combustion;
           instruments
       In 1917, Thornton showed that for a large number of organic liquids and gases, a more or less constant net amount of
       heat is released per unit mass of oxygen consumed for complete combustion. Huggett found this to also be true for
       organic solids and obtained an average value for this constant of 13.1 MJkg-1 of O2. This value may be used for practical
       applications and is accurate with very few exceptions to within +5%.

90.   Jason, N. H.
       Building and Fire Research Laboratory Publications, 1991.
       National Institute of Standards and Technology, Gaithersburg, MD
       NISTIR 4827;   136 p. April 1992.
       Available from National Technical Information Services
       PB93-116465

           building research; building technology; cements; earthquakes; fire models; fire detection; polymethylmethacrylate

Building and Fire Research Publications, 1991 is the second edition to reflect the combined publications of the Building and Fire Research Laboratory (BFRL) for calendar year 1991. In 1991 the Center for Building Technology (CBT) and the Center for Fire Research (CFR) were combined to form BFRL. This publication is a supplement to building and Fire Research Laboratory Publications, 1990 and previous editions of Fire Research Publications and the Building Technology Publications. Contact the author if you would like information about the earlier editions. Only publications prepared by the members of the BFRL staff, by other National Institute of Standards and Technology (NIST) personnel for BFRL, or by external laboratories under contractor grant from the BFRL are cited. NIST Report series are available for purchase from either the Government Printing Office (GPO) or the National Technical Information Service (NTIS). GPO documents, e.g., the NIST Technical Note series, are obtained by writing directly to the Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402. Orders must be payable to the "Superintendent of Documents, U. S. Government Printing Office". Major credit cards also may be used. NTIS documents, i.e, the NISTIR and NIST-GCR series, are obtained by writing directly to the National Technical Information Service, Springfield, VA 22161. Microfiche copies of the documents also are available at a cost of approximately $12.00 for domestic orders. Orders must be prepared by check or money order payable to "National Technical Information Service" or by utilizing your NTIS deposit account. Major credit cards also may be used.

91.   Jason, N. H.
       Fire Information Challenges of the 21st Century. Conference Report.
       National Institute of Standards and Technology, Gaithersburg, MD
       Fire Technology, Vol. 28, No. 3, 283-284, August 1992 AND SFPE Bulletin, 5, July/August
       1992.
              bibliographic databases; fire research; computers; information dissemination
       Two recent conferences, the First International Fire Information Conference (IFIC) held at Moreton-in-Marsh,
       Gloustershire, England, April 27-May 1, 1992 and the Conference for Exploration of a National Engineering Information
       Service, held at Palm Coast, Florida, June 14-19, 1992 illustrate how the information field, and specifically the fire
       information field, is preparing itself, the fire protection engineer and the fire scientist for the challenges of the 21st
       Century. According to research cited at the Exploration conference, over $8.2 billion is spent annually in support of
       information access by engineers. This figure takes into account the cost of time spent by engineers in seeking and accessing
       information vital to their daily activities. Even a small improvement in efficiency in this process could return substantial
       savings.

92.   Jason, N. H.
       Summaries of BFRL Fire Research In-House Projects and Grants, 1992.
       National Institute of Standards and Technology, Gaithersburg, MD
       NISTIR 4918;   179 p. September 1992.
       Available from National Technical Information Services
       PB93-116390
              building technology; charring; combustion; fire models; flame spread; blowout fires; hazards; fire research;
              ignition; polymers; soot; smoke; sprinklers
       This report describes the research projects performed in the Building and Fire Research Laboratory (BFRL) Fire
       Research Program and under its grants program from October 1, 1991 through September 30, 1992.

93.   Jolly, S.; Saito, K.
       Scale Modeling of Fires With Emphasis on Room Flashover Phenomenon.
       Kentucky Univ., Lexington
       Fire Safety Journal, Vol. 18, No. 2, 139-182, 1992.
              flashover; scale models; fire behavior; small scale fire tests; pool fires; crib fires; mass fires; fire plumes; flame
              whirls; flame spread

94.   Jones, W. W.; Forney, G. P.
       Modeling Smoke Movement Through Compartmented Structures.

National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4872;   34 p. July 1992.
Available from National Technical Information Services
PB92-213313

> smoke; compartment fires; fire growth; mathematical models; numerical models; room fires; toxicity
>
> This paper describes a model of fire growth and smoke transport for compartmented structures, with emphasis on those aspects which are important to making correct predictions of smoke movement in multicompartment structures. In particular, we are interested in the ability to model the movement of toxic gases from the room of origin of a fire to a distant compartment. The newest phenomena in the model are vertical flow and mechanical ventilation. Finally, we have improved the radiation transport scheme which affects energy distribution, and therefore the buoyancy forces. These are very important in a actual situations relevant to fire growth and smoke propagation, as is demonstrated.

95.   Kao, J. Y.
HVAC Functional Inspection and Testing Guide.
National Institute of Standards and Technology, Gaithersburg,MD
NISTIR 4758;   429 p. March 1992.
Available from National Technical Information Services
PB92-173012

> heating; ventilation; air conditioning; air handling system test; building automation system test; commissioning; field test; fire safety; functional test; heating plant test; inspection; smoke control test; refrigeration plant test
>
> This guide is developed for the Public Building Service (PBS) of the General Administration (GSA) for final inspection and testing of heating, ventilating, and air-conditioning (HVAC) systems in Federal buildings prior to Government acceptance. The guide describes in detail the functional inspection and testing procedures and calculations. It includes eight chapters: General, Basic Management, Refrigeration Plant, Heating Plant, Air Handling Equipment and Systems., Building Automation Systems, Fire Safety Air Moving Systems, and Unitary Air Conditioning Equipment. The appendix contains detailed inspection checklist and test work sheets designed to be used in the field.

96.   Kashiwagi, T; Nambu, H.
Global Kinetic Constants for Thermal Oxidative Degradation of a Cellulosic Paper.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 88, No. 3-4, 345-368, 1992.

> kinetics; thermal oxidative; degradation
>
> Values of global kinetic constants for pyrolysis, thermal oxidative degradation, and char oxidation of a cellulosic paper were determined by a derivative thermal gravimetric study. The study was conducted at heating ranges of 0.5, 1, 1.5, 3, and 5 deg C/min in ambient atmospheres of nitrogen, 0.28%, 1.08%, 5.2% oxygen concentrations and air. Sample weight loss rate, concentrations of CO, CO_2 and H_2O in the degradation products, and oxygen consumption were continuously measured during the experiment. Values of activation energy, pre-exponential factor, orders of reaction and yields of CO, CO_2, H_2), total hydrocarbons, and char for each degradation reaction were derived from the results. Heat of reaction for each reaction was determined by differential scanning calorimetry. A comparison of the calculated CO, CO_2, H_2O, total hydrocarbons, sample weight loss rate, oxygen consumption was made with the measured results using the derived kinetic constants and accuracy of the values of kinetic constants was discussed.

97.   Kedzierski, M. A.
Simultaneous Visual and Calorimetric Measurements of R11, R123, and R123/Alkylbenzene Nucleate Flow Boiling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4948;   54 p. October 1992.
Available from National Technical Information Services
PB93-120756

refrigerants; alkylbenzene; alternative refrigerants; boiling; bubble parameters; building technology; calorimetric; chemistry; dichlorotrifluoroethane; trichlorofluoromethane; visualization

Bubble formation during horizontal flow boiling of trichlorofluoromethane (R11), 1,1-dichloro-2,2,2-trifluoroethane (R123) and two R123/alkylbenzene lubricant mixtures was investigated both visually and calorimetrically. The test fluid was pumped through the inside of a roughened, horizontal, quartz tube which was electrically heated with a metal strip. The refrigerant entered the test section with a quality slightly above the saturated state. Locally measured heat transfer coefficients were taken simultaneously with high speed motion picture images of the boiling process. Predictive equations from the literature yielded acceptable agreement with the measured bubble diameters and contact angles. The addition of lubricant to the R123 increased the size of the contact angle and reduced the size of the bubble. The agreement between existing correlations and the measured bubble frequencies and site densities was within the uncertainty of the measurements. The addition of a small amount (0.5%) of alkylbenzene to R123 increases the number of active nucleation sites by approximately 5 sites/cm2 which corresponds to a 12% to 50% increase in the site density. The increase in the site density contributed to the enhancement of the heat transfer coefficient of the R123/0.5% alkylbenzene mixture over that of the pure R123. Further increase in the amount of alkylbenzene to the R123 reduces the number of active sites to below that of pure R123 to approximately the value for that of R11. Consequently, the 0.5% lubricant mass fraction mixture exhibited a heat transfer coefficient that was larger than that of the 2% lubricant mass fraction mixture. Correspondingly, the lower heat transfer coefficient of R11 as compared to that of R123 was partially due to the lower number of active boiling sites for R11. The dependency of the measured two-phase heat transfer coefficient on the heat flux and Reynolds number was investigated. Increases in both the heat flux and the Reynolds number caused increases in the heat transfer coefficient. The heat flux has a much larger effect on the heat transfer coefficient than the Reynolds number.

98.   Kedzierski, M. A.; Kim, J. H.; Didion, D. A.
        Causes of the Apparent Heat Transfer Degradation for Refrigerant Mixtures.
        National Institute of Standards and Technology, Gaithersburg, MD
        Electric Power Research Inst., Palo Alto, CA
        American Society of Mechanical Engineers. Two-Phase Flow and Heat Transfers, 1992.
        National Heat Transfer Conference, 28th. August 9-12, 1992, HTD-Vol. 197, San Diego, CA,
        ASME, New York, Kim, J. H.; Nelson, R. A.; Hashemi, A., Editors, 149-158 pp, 1992.

refrigerants; heat transfer; degradation; evaporation; temperature distributions; mixing

This paper presents an investigation into the causes of the apparent heat transfer degradation associated with horizontal-annular flow evaporation of refrigerant mixtures. The apparent heat transfer degradation is the difference between the measured heat transfer coefficient and the heat transfer coefficient that would be obtained from a linear interpolation of the single component values. The degradation is apparent since the linearly interpolated values have no physical basis. For horizontal-annular flow evaporation, most of the heat transfer degradation is a consequence of the use of the locally uniform equilibrium temperature in the measurement an calculation of the heat transfer coefficient. In reality, both circumferential and radial composition gradients can exist within the liquid film which cause temperature distributions that deviate significantly from a uniform saturation temperature. If the actual liquid-vapor interface temperatures (local vapor temperatures) were used in the calculation of the measured heat transfer coefficient for the impose heat flux condition, most of the apparent degradation would not exist. The remainder of the heat transfer degradation is due to nonlinear mixture property effects. Previously published measured heat transfer coefficients for three mixtures were investigated. The focus of the study was to determine the magnitude and the cause of the individual components of the heat transfer degradation of the studied mixture.

99.   Kelly, G. E.; May, W. B.; Kayo, J. Y.; Park, C.
        Guidelines for Using Emulators to Evaluate the Performance of Energy Management and
        Control Systems.
        National Institute of Standards and Technology, Gaithersburg, MD
        NISTIR 4991;   58 p. November 1992.
        Available from National Technical Information Services
        PB93-138931

emulator; algorithms; building/HVAC/plant system; building energy management system; energy management and control system; performance evaluation; simulation; test and rating methodology

A Building Energy Management System (BEMS) is that portion of a Building Automation System (BAS) that control the heating, ventilation, and air conditioning (HVAC) systems in buildings. Its performance is directly related to the amount of energy consumed in a building and the comfort of the building occupants. One approach to evaluating the performance of an BEMS is through the use of an Emulator. This is a special computer/data acquisition system that is connected to the sensor inputs and command outputs of the BEMS. It replaces the HVAC system and building and uses a computer program to simulate their response to BEMS commands. The BEMS, through its supervisory and/or direct digital control algorithms, then controls the simulated building/HVAC system as if it were an actual one. At the same time the Emulator evaluates the performance of the BEMS in terms of the energy consumed by the simulated building, the degree of comfort maintained in the simulated space, response time, accuracy, etc. This report contains guidelines for using Emulators to evaluate an BEMS. An overview of the hardware and software found in a typical BEMS is presented, followed by information on: setting up an BEMS and an Emulator, evaluating system/command and DDC software, and methodologies for testing BEMS application algorithms. Considerations are also presented for evaluating an BEMS' programming capabilities, DDC control loop performance, and for rating different aspects of an BEMS's performance.

100. Klassen, M.; diMarzo, M.; Sirkis, J.
Infrared Thermography of Dropwise Evaporative Cooling.
Maryland Univ., College Park
Experimental Thermal and Fluid Science, Vol. 5, No. 1, 136-141, 1992.
American Institute of Aeronautics and Astronautics/American Society of Mechanical
Engineers (AIAA/ASME). Heat and Mass Transfer in Fires. AIAA/ASME Thermophysics
and Heat Transfer Conference. June 18-20, 1990, HTD-Vol. 141, Seattle, WA, Am. Soc.
of Mechanical Engineers, New York, Quintiere, J. G.; Cooper, L. Y., Editors, 117-121 pp,
1990.

> heat transfer; mass transfer; evaporation; cooling; temperature distribution; droplets; data processing; infrared thermography; droplet flow; image processing

An infrared thermographic technique is developed to obtain the transient solid surface temperature distribution in the neighborhood of an evaporating droplet. This technique is nonintrusive and is not affected by the time response of the measuring device (i.e., thermocouple). The entire surface is monitored at any instant of time, and information on the area influenced by the evaporative cooling process is easily derived. A detailed description of the image processing based data reduction is provided. A water droplet in the range of 10-50 muL is deposited on an opaque glasslike material (Macor) that has an initial surface temperature between 100 and 165 deg C. The evaporative cooling process is fully documented, and these new findings are contrasted with the published literature to gain a better understanding of the phenomena involved.

101. Klassen, M.; Sivathanu, Y. R.; Gore, J. P.
Simultaneous Emission Absorption Measurements in Toluene-Fueled Pool Flames: Mean and
RMS Properties.
Purdue Univ., West Lafayette, IN
Combustion and Flame, Vol. 90, No. 1, 34-44, 1992.

> toluene; soot; temperature; flame structure; spectral absorptivity; spectral emissivity; pool fires; radiative heat transfer; burning rate

Local measurements of mean and RMS emission intensities, transmittances, emission temperature, and soot volume fractions based on emission and absorption in toluene flames burning in a pool configuration are reported. Radical profiles of these quantities at six axial stations within the flame are selected for discussion. The results show large fluctuations in temperatures and soot volume fractions at all locations including those near the liquid surface. Differences between the soot volume fractions based on emission and those based on absorption indicate the presence of large quantities of relatively cold soot at all positions.

102. Klote, J. H.
Preview of ASHRAE's Revised Smoke Control Manual.
National Institute of Standards and Technology, Gaithersburg, MD

ASHRAE Journal, Vol. 34, No. 11, 34-37, November 1992.

103.   Klote, J. H.; Alvord, D. M.
Routine for Analysis of the People Movement Time for Elevator Evacuation.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4730;   67 p.   February 1992.
Available from National Technical Information Services
PB92-164771

This paper is part of a project sponsored by the U. S. General Services Administration (GSA) to study occupant use of elevators during building evacuations. A detailed method of analysis of people movement by elevators during emergency building evacuation is presented including the time for people to enter and exit elevators and the equations of elevator car motion. Also a computer program for people movement during elevator evacuation and examples. Runs of this are listed in appendices. The method and computer routine presented in this paper are intended to be used in a later part of the GSA elevator project to help study the feasibility of elevator fire evacuation.

104.   Klote, J. H.; Alvord, D. M.; Levin, B. M.; Groner, N. E.
Feasibility and Design Considerations of Emergency Evacuation by Elevators.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4870;   126 p. February 1992.
Available from National Technical Information Services

Throughout most of the world, warning signs next to elevators indicate they should not be used in fire situations, and today's elevators have not been designed for fire evacuation and should not be used for fire evacuation. However, the idea of using elevators to speed up fire evacuation and to evacuate persons with disabilities has gained considerable attention. The potential of elevator evacuation is so significant that the U. S. General Services Administration (GSA) has sponsored a research project at NIST to develop techniques for occupant use of elevators during building evacuations. This paper is the final report of that project, and it addresses fundamental system considerations, engineering design consideration, design analysis, and human behavior. This paper shows that use of elevators in addition to stairs during a fire emergency allows occupants and firefighters an additional system of vertical transportation. Even through the focus of this paper is fire evacuation, much of the information is also applicable to evacuation for other emergencies. The results of a previous project to develop smoke control of elevator systems are presented in Appendix A. An interactive computer program ELVAC, was written specifically for the analyses of this paper.

105.   Klote, J. H.; Milke, J. A.
Design of Smoke Management Systems.
National Institute of Standards and Technology, Gaithersburg, MD
Maryland Univ., College Park
236 p. 1992.
Available from American Society of Heating, Refrigerating, and Air-Conditioning
Engineers, Inc. (ASHRAE), 1791 Tullie Circle, N. E., Atlanta, GA 30329

In 1983 ASHRAE published Design of Smoke Control Systems for Buildings by myself and John Fothergill. This book was the first attempt to consolidate and present practical information for smoke control design. Judging by the many favorable comments and suggestions about this first publication, I feel that it was a success. The first publication was limited to systems that control smoke by means of airflow and pressurization, but this new publication also addresses

systems using compartmentation, dilution, and buoyancy. The term smoke management is used to emphasize the broader range of mechanisms and approaches in this new book. In addition to addressing the mechanisms of smoke management, almost all the material that was in the first publication has been revised and expanded. My coauthor, Jim Milke, and I have attempted to keep up with the many advances in management research and with those due to the ingenuity and creativity of designers and other professionals. Since 1983, there have been many advances in this technology, especially in elevator pressurization, exhaust systems for atria, stairwell pressurization, and zoned smoke control. Elevator pressurization was the subject of a joint project between myself at the National Institute of Standards and Technology in the U. S. and George Tamura of the National Research Council of Canada. We developed elevator pressurization system concepts, conducted fire experiments at the 10-story Canadian fire tower, and presented design information. The recent efforts in atrium smoke control by Gunner Heskestad of Factory Mutual in the United States and Howard Morgan of the Fire Research Station in the United Kingdom were built on a solid engineering foundation of shopping mall technology pioneered in the United Kingdom in the 1970s. Insight has been gained about stairwell pressurization from a series of experiments conducted by George Tamura at the 10-story Canadian fire tower. Much was learned about zoned smoke control by a series of full-scale fire experiments I conducted in the Plaza Hotel Building in Washington, D. C. As with the first publication, I hope this book is of value to the engineering community.

106.   Klote, J. H.; Nelson, H. E.; Deal, S.; Levin, B. M.
Staging Areas for Persons With Mobility Limitations.
National Institute of Standards and Technology, Gaithersburg, MD
George Mason Univ., Fairfax, VA
NISTIR 4770;   186 p. February 1992.
Available from National Technical Information Services
PB92-171891

> handicapped; life safety; evacuation; flashover; office buildings; refuge; smoke barriers; smoke control; smoke hazards; sprinkler systems; egress; staging areas

The National Institute of Standards and Technology (NIST) is engaged in a project funded by the General Services Administration (GSA) to evaluate the concept of staging area as a means of fire protection for persons with disabilities as it applies to Federal office buildings. There is a rising concern for the safety from fire of persons who can not travel the building emergency exit routes in the same manner or as quickly as expected of able persons. One proposed solution for providing safety for persons with such disabilities is the provision of staging areas where they can "safely wait" until they can be assisted in safely leaving the building. The GSA has modified six buildings for fire protection of persons with mobility disabilities. Spaces that were turned into staging areas include passenger elevator lobbies, service elevator lobbies, sections of corridor, and rooms. Because these six GSA buildings were the first buildings ever to be retrofitted as discussed above, there were no precedents upon which to base the design or operation of the systems. Before this study the extent of the complexity of these systems and the interaction between the systems and people were unknown. It is not surprising that significant operational problems were uncovered with these first systems. These unavoidable problems coupled with the diversity of the applications in the six buildings resulted in a unique opportunity to learn about these systems. The conclusions were: (1) staging areas can be either a haven of safety or a death trap; (2) in many cases, the persons most needing the staging area protection may be unable to reach that area before their pathway (corridor or aisle ways) become lethal; and (3) the operation of a properly designed sprinkler system eliminates the life threat to all occupants regardless of their individual abilities.

107.   Kolos, R. M.
Compressive Strengths of Hydraulic Cements Produced in the United States.
National Institute of Standards and Technology, Gaithersburg, MD
Cement, Concrete, and Aggregates, Vol. 14, No. 2, 127-130, Winter 1992.

> cements; compressive strength; portland cement; masonry

The subcommittees of ASTM Committee C1 on Cement that have responsibility for specifications for portland cement, blended cement, and masonry cement requested that Subcommittee C01.27 on Strength collect statistical data on the compressive strength of cements currently produced in the United States that met the 1989 requirements of ASTM Specification for Portland Cement (C 150), ASTM Specification for Blended Hydraulic Cements (C 595), or ASTM Specification for Masonry Cement (C 91). The last survey of this type was conducted in 1964 by Subcommittee C01.27. Based on this request, Subcommittee C01.27 surveyed 128 producers in the United States and received 98 replies. The

survey forms were mailed to the producers in July 1990, and the results from the survey were reported to Subcommittee C01.27 at its December 1990 meeting. The purpose of this paper is to describe the survey and to present the results.

108. Kramer, T. R.; Palmer, M. E.; Feeney, A. B.
Issues and Recommendations for a STEP Application Protocol Framework.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4755; 90 p. January 192.
Available from National Technical Information Services

application protocol; framework; information; modeling; PDES; STEP

Technical experts are developing the next generation of product information exchange standards, called the Standard for the Exchange of Product Model Data (STEP). The STEP project is using the application protocol (AP) methodology for defining the information requirements of industry. Several STEP APs have been drafted. Before more APs are developed, the methods for developing and testing APs must be proven. This report provides a summary of AP development issues, a listing of the relevant documentation and issues papers, lessons learned from AP projects, and a set of recommendations for resolving the identified issues. This includes recommendations on AP scope definition, AP classification, elements of the AP structure, and elements of a AP framework.

109. Krayer, W. R.; Marshall, R. D.
Gust Factors Applied to Hurricane Winds.
National Institute of Standards and Technology, Gaithersburg, MD
Bulletin of the American Meteorological Society, Vol. 73, No. 5, 613-617, May 1992.

wind velocity; weather effects; structural design

An important consideration in the design of structures is their response to extreme winds. This is especially true in regions affected by hurricanes. In this research, gust factors derived from hurricane wind-speed records are compared with those derived by Durst and others from open-scale records obtained in well-developed, extratropical storms. Based on records obtained from four hurricanes and 11 different recording stations, it is concluded that an upward adjustment of the Durst gust factors for the estimation of hurricane gust speeds may be in order. Anomalously high gust factors observed for hurricane winds in inland areas suggest the need for additional study. Also, it is concluded that a reexamination of the statistics of gust factors obtained from extratropical storm data would be useful in clearly identifying the appropriate probability distribution function.

110. Kushida, G.; Baum, H. R.; Kashiwagi, T.; diBlasi, C.
Heat and Mass Transport From Thermally Degrading Thin Cellulosic Materials in a Microgravity Environment.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Heat Transfer, Vol. 114, No. 2, 494-502, May 1992.

cellulosic materials; reduced gravity

A theoretical model describing the behavior of a thermally thin cellulosic sheet which is heated by external thermal radiation in a quiescent microgravity environment is developed. This model describes thermal and oxidative degradation of the sheet and the heat and mass transfer of evolved degradation products form the heated cellulosic surface into the gas phase. At present, gas phase oxidation reactions are not included. Without buoyancy, the dominant vorticity creation mechanism in the bulk of the gas is absent except at the material surface by the requirement of the no-slip condition. The no-slip condition is relaxed, permitting the flow to be represented by a velocity potential. This approximation is permissible due to the combination of a microgravity environment and low Reynolds number associated with slow small-area heating by external radiation. Two calculations are carried out; heating without thermal degradation and heating with thermal degradation of the sheet with endothermic pyrolysis, exothermic thermal oxidative degradation and highly exothermic char oxidation. The results show that pyrolysis is the main degradation reaction. Moreover, self-sustained propagation of smoldering for cellulosic materials is very difficult due to the lack of sufficient oxygen supply in a quiescent environment.

111. Lawson, J. R.
Evaluation of Precision for the ASTM E648-91A Standard Test Method for Critical Radiant Flux of Floor-Covering Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4799;   34 p. August 1992.
Available from National Technical Information Services
PB92-238682

floor coverings; ASTM E 648; carpets; critical radiant flux; fire tests; flammability; interlaboratory evaluation; precision

The primary goal of this project was to develop data to be used in writing a precision statement for the newly revised ASTM E 648 test procedure. Revisions to the standard included the use of a new line pilot burner, improved control over air flow through the test chamber and an extended chamber equilibration time before the apparatus is calibrated. An interlaboratory test program was conducted to develop the precision data. In this study, seven laboratories performed tests on seven sets of flooring materials. Six carpets and one resilient flooring material were selected for the evaluation. The interlaboratory study was designed and carried out using procedures recommended in ASTM E 691 standard on interlaboratory studies. Results from the program show that precision for the revised ASTM E 648 method is generally well within the range expected for standard fire test procedures. Coefficients of variation for repeatability ranged from 2.2 to 19.7 percent, and coefficients of variation for reproducibility ranged from 3.6 to 25.2 percent. In addition to these findings, a carpet variability problem appears to have been identified. A large variation in test results for two carpet products appears to be associated with carpet non-uniformity. Recommendations are made for research to develop an understanding of the variations associated with the specific style of carpeting. Recommendations are also made for studies to further improve the test standard.

112. Lechner, J. A.; Leigh, S. D.; Simiu, E.
Estimates of Extreme Wind Distribution Tails.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Civil Engineers. Probabilistic Mechanics and Structural and Geotechnical Reliability. Proceedings of the 6th Specialty Conference. July 8-10, 1992, Denver, CO, American Society of Civil Engineers, New York, NY, 276-279 pp, 1992.

wind effects; structures; wind velocity; wind direction; failure

The assumption that extreme winds have a Gumbel distribution appears to yield unrealistically high failure probability estimates for wind-sensitive structures. For this reason we study the question of whether extreme winds are better fitted by distributions with finite or shorter tails. We report progress in the following areas: (1) use of the Pickands and Conditional Mean Exceedance methods for estimating the tail length; (2) application of these methods to epochal (largest annual) wind speeds; (3) comparisons of results so obtained with results obtained from simulated sets of data; (4) application of these methods and the Dekkers-Einmahl-de Haan method to non-epochal extremes. Preliminary results suggest that for most U. S. weather stations not pron to hurricane winds, reverse Weibull distributions (which have finite tails) fit extreme wind data sets better than the Gumbel distribution (which has infinite tail). However, the significance of these results remains to be evaluated, and more precise methods for estimating tail length need to be used. Also needed are additional studies based on non-epochal and simulated data.

113. Lechner, J. A.; Leigh, S. D.; Simiu, E.
Recent Approaches to Extreme Value Estimation With Application to Wind Speeds. Part 1. The Pickands Method.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Wind Engineering and Industrial Aerodynamics, Vol. 41, No. 44, 509-519, 1992.

wind velocity

The last 15 years have seen the development of a new body of theory and of a new generation of statistical estimation procedures applicable to extreme data. Essentially these approaches emphasize the primacy of the information concerning the largest of the extremes (the tails), as opposed to information inherent in the bulk of the extreme data (the body of the distribution). One potentially attractive feature of some of these approaches is that, in principle, they make it possible to ascertain whether the distribution that best fits a given set of extreme data has a finite tail.

114. Leonard, J. T.; Budnick, E. K.; Back, G. C.; Ganey, S. J.
Development of a Video Image-Based Methodology for Estimating Large Scale Transient Hydrocarbon Smoke Plume Size and Extent.
Naval Research Laboratory, Washington, DC
Hughes Associates, Inc., Columbia, MD
NIST-GCR-92-614;   186 p. August 1992.
Available from National Technical Information Services

> smoke plumes; computer programs; crude oil; field models; fire tests; pattern recognition; wind velocity
>
> Interest in burning crude oil as a means to mitigate large scale oil spills at sea led to mid-scale evaluation of relevant crude oil burning characteristics. As part of this effort, a computer-based field measurement technique for estimating the size, shape, and extent of visible smoke plumes was developed. Of the experiments in which measurements were made, Test 7 provided data on plume trajectory for the largest distance from the pan. Good agreement was obtained between corresponding 35 mm photographs and digitized images used to estimate plume volume and trajectory. In Test 7, at 600 s after ignition, the leading edge of the smoke plume had risen to 780 m and traveled 1800 m downwind from the pan. The estimated total volume of the smoke plume at 600 s after ignition was 3.8×10^8 m3. At that time, the total volume of the smoke plume was increasing at a rate of 3.2×10^6 m3/s. Limited evaluation indicates that the MS-DOS based method provides reasonably accurate estimates of visible smoke plume geometry in the near-field. Field accuracy depends on plume size, wind speed and direction, and the resolution of the equipment.

115. Levin, B. C.
Development of a New Small-Scale Toxicity Test Method and Its Comparison With Full-Scale Fire Tests.
National Institute of Standards and Technology, Gaithersburg, MD
Toxicology Letters, Vol. 64/65, 257-264 Supplement 1992.
Abstracts of the 6th International Congress of Toxicology. June 28-July 3, 1992, Abstract S5/L2, Rome, Italy, 1992.

> toxicity test methods; large scale fire tests; methodology; fire hazards; hazard analysis; smoke; toxic gases; rats
>
> A comprehensive methodology has been developed for obtaining and using smoke toxicity data for fire hazard analysis. This bench-scale method can simulate diverse fire conditions and identify extremely toxic smoke under both pre- and post-flashover conditions. However, incidence data show that most of the fire deaths in the U. S. occur outside the room of fire origin from smoke and toxic gases that are generated from a fire under post-flashover conditions. Therefore, the most relevant real-scale combustion conditions to simulate in the bench-scale apparatus would be the post-flashover conditions which are achieved by using radiant heat, a high heat flux, and correcting the bench-scale carbon monoxide (CO) results to agree with CO yields observed in real-scale post-flashover fires. The number of test animals (Fischer 344 male rats) is minimized by using the N-Gas Model to estimate the LC50 value from the chemical analysis of the smoke. The current N-Gas Model predicts the toxicity of complex fire gas mixtures based on a large data base of experimental results of individual and mixed gases that include CO, CO2, reduced O2, HCN, HCl, HBr, and NOx. The prediction is checked with a small number of animal tests and an approximate LC50 value is determined. The bench-scale results have been validated with full-scale room wall burns of a limited number of materials of widely differing characteristics chosen to challenge the system. The toxic potency values are assessed to determine if the smoke from a material or product is unusually or extremely toxic and can then be used in computations of fire hazard.

116. Levin, B. C.; Alarie, Y.; Stock, M. F.; Schiller, S. B.
Development of a Standard Reference Material for Calibration of the University of Pittsburgh Smoke Toxicity Method for Assessing the Acute Inhalation Toxicity of Combustion Products.
National Institute of Standards and Technology, Gaithersburg, MD
Pittsburgh Univ., PA
Journal of Research of the National Institute of Standards and Technology, Vol. 97, No. 2, 245-252, March/April 1992.

> combustion products; combustion; inhalation; standard reference materials; toxicity test methods; nylon (trademark)

A standard reference material (SRM 1049) has been developed for the University of Pittsburgh smoke toxicity method. SRM 1049 is a nylon 6/6 and has the molecular structure of [-NF(CH2)6NHCO(CH2)4CO-]. This SRM is for calibrating the apparatus and providing confidence that the method is being conducted in a correct manner and that the equipment is functioning properly. The certified figure of merit is a LC50 value plus its 95% prediction interval which were calculated and found to be 4.4+3.4g. The 95% prediction interval indicates the range in which the next determined LC50 value would be expected to fall. Thus, if an investigator were to test this SRM under their laboratory conditions according to the specifications of the University of Pittsburgh test procedure and found the LC50 value fell within the certified 95% prediction interval, the probability is good that the test is being conducted correctly.

117. Levin, B. C.; Braun, E.; Paabo, M.; Harris, R. H., Jr.; Navarro, M.
Reduction of Hydrogen Cyanide Concentrations and Acute Inhalation Toxicity From Flexible Polyurethane Foam Combustion Products by the Addition of Copper Compounds. Part 4. Effects of Combustion Conditions and Scaling on the Generation of Hydrogen Cyanide and Toxicity From Flexible Polyurethane Foam With and Without Copper Compounds.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4989;   114 p. December 1992.
Available from National Technical Information Services
PB93-139103

hydrogen cyanide; acute toxicity; combustion products; copper; polyurethane foams; melamine

Two full-scale protocols (A & B) were tested to determine the efficacy of cuprous oxide (Cu2O) in reducing the concentrations of hydrogen cyanide (HCN) from flexible polyurethane foams (FPU) when thermally decomposed under "realistic" room conditions. In each Protocol A test, a FPU cushion (untreated or treated with 0.1% Cu2O) was cut in half, and the two halves were stacked on a load cell in a closed room. The ignition source was a hot wire placed between the two halves. Rats were exposed to the decomposition products to examine the toxicological effects of the foams with and without Cu2O. Protocol B differed from Protocol A in that chairs were simulated by four FPU cushions attached to a steel frame; the treated FPU contained 1.0% Cu2O; the cushions were covered with a cotton fabric; the chairs were ignited with cigarettes; and the burn room was open and connected to a corridor. In both protocols, the thermal decomposition progressed through nonflaming, smoldering and flaming phases and the concentrations of HCN and other gases were monitored. Foams used in the full-scale room burns were also examined under small-scale conditions (under flaming or a two-phase nonflaming/ramped heating mode) in the cup furnace smoke toxicity method. Both atmospheric and reduced O2 conditions were studied. The small-scale tests showed an 87% reduction in the concentration of HCN and a 40 to 73% reduction in the toxicity of the thermal decomposition products when the Cu2O-treated foams were tested. In the full-scale tests, the concentration of HCN was reduced 70% when the FPU contained 1.0% Cu2O, but not when the foams contained 0.1% Cu2O. Investigation into this discrepancy indicated that exposing the charred residues from the full-scale burn room tests to the ramped heating mode in the cup furnace smoke toxicity method would produce significant amounts of HCN (65-90 ppm) from the untreated foam chars and only 1-2 ppm from the 0.1% Cu2O-treated foam chars indicating that the copper even at this low concentration was still active in reducing HCN generation. Some preliminary experiments comparing a melamine-treated and standard FPU foam (both without Cu2O) in the two phase cup furnace smoke toxicity method showed 10 times more HCN generated by the melamine-treated FPU than the standard FPU and a 90% reduction of HCN from the melamine-treated FPU when it was treated with Cu2O.

118. Levin, B. C.; Gann, R. G.; Babrauskas, V.; Paabo, M.; Harris, R. H., Jr.; Peacock, R. D.; Yusa, S.
New Approach for Toxic Potency Measurement for Fire Hazard Analysis.
National Institute of Standards and Technology, Gaithersburg, MD
Toxicologist, Vol. 12, No. 1, 237, February 992.

fire hazard; hazard analysis; toxicity; smoke; toxic gases; flashover; carbon monoxide; animals; rats

A comprehensive methodology has been developed for obtaining and using smoke toxicity data for fire hazard analysis. This bench-scale method can simulate diverse fire conditions and identify extremely toxic smoke under both pre- and post-flashover conditions. However, incidence data show that most of the fire deaths in the U. S. occur outside the room of fire origin from smoke and toxic gases that are generated from a fire under post-flashover conditions. Therefore, the most relevant real-scale combustion conditions to simulate in the bench-scale apparatus would be the post-flashover conditions which are achieved by using radiant heat, a high heat flux, and correcting the bench-scale carbon monoxide

(CO) results to agree with CO yields observed in real-scale post-flashover fires. The number of test animals (Fischer 344 male rats) is minimized by using the N-Gas Model to estimate the LC50 value from the chemical analysis of the smoke. The current N-Gas Model predicts the toxicity of complex fire gas mixtures based on a large data base of experimental results of individual and mixed gases that include CO, CO2, reduced O2, HCN, HCl, HBr, and NO2. The prediction is checked with a small number of animal tests and an approximate LC50 value is determined. The bench-scale results have been validated with full-scale room wall burns of a limited number of materials of widely differing characteristics chosen to challenge the system. The toxic potency values are assessed to determine if the smoke from a material or product is unusually or extremely toxic and can then be used in computations of fire hazard.

119.   Levin, B. M.; Groner, N. E.; Paulsen, R.
       Affordable Fire Safety in Board and Care Homes: A Regulatory Challenge. Interim Report.
       George Mason Univ., Fairfax, VA
       NIST-GCR-92-611;   63 p. May 1992.
       Available from National Technical Information Services
       PB92-205483
              board and care homes; fire safety; costs; fire codes; human behavior; planning
       This is an interim report on a project concerning fire safety in Board and Care Homes. Homes vary greatly in the level of disability of residents and financial resources of the residents. A major concern is the availability of satisfactory care for clients with limited funds. Meeting fire safety codes can mean an unaffordable capital cost to financially marginal providers who cannot borrow money. One focus of the study is the use of the provisions in the Life Safety Code. Many agencies use these requirements and find they lead to a high level of safety without excessive costs. All have developed or adopted a procedure for rating Evacuation Difficulty that they find workable, and many find satisfactory. Other agencies use other requirements, sometimes more lenient and often more strict. Costs of fire safety systems, such as sprinklers, can vary greatly, impending a dialogue on the benefit-cost relationships of these systems. It appears that in some locations there are many homes that provide the services of Board and Care Homes but are not regulated.

120.   Levin, B. M.; Groner, N. E.
       Human Behavior Aspects of Staging Areas for Fire Safety in GSA Buildings. Final Report.
       George Mason Univ., Fairfax, VA
       NIST-GCR-92-606;   58 p. April 1992.
       Available from National Technical Information Services
       PB92-187129
              human behavior; fire safety; fire protection; handicapped; high rise buildings; office buildings; staging areas;
              egress; evacuation
       One approach for assuring the safety of disabled occupants of office buildings, in a fire emergency, is to provide a staging area or an area of refuge where the disabled occupants can wait safely until either they can be assisted out of the building or the fire is extinguished. GSA has retrofitted six office buildings with staging areas to upgrade the fire safety for disabled occupants. This is a report of a project to study the six installations to determine the feasibility of staging areas from a human behavior perspective and to make recommendations for upgrading current and future installations. The study showed that government employees will accept and use staging areas. The study revealed: the need to pay attention to details in designing the communications system; the need for training the emergency team and informing the occupants; and the need for special procedures for maintenance.

121.   Lin A. N.; Shenton, H. W., III
       Seismic Performance of Fixed-Base and Base-Isolated Steel Frames.
       National Institute of Standards and Technology, Gaithersburg, MD
       Journal of Engineering Mechanics, Vol. 118, No. 5, 921-941, May 1992.
              steel frames; frame design; earthquakes; mathematical models; time histories; base shear; braced frame; moment
              frame
       The seismic performance of fixed-base and base-isolated concentrically braced and special moment-resisting steel frames are determined. The fixed-base frames are designed in accordance with the 1990 Structural Engineers Association of California (SEAOC) Recommended Lateral Force Requirements and Commentary, while the base-isolated frames are designed to 100%, 50%, and 25% of the SEAOC-recommended lateral force levels. Nonlinear time-history analyses, for

54 ground motion records, are then conducted. The number of yielded or collapsed frames, number of yielded elements, total and relative roof displacement, and isolation-bearing displacement are statistically evaluated. Comparable or better performance is achieved for the base-isolated braced frame designed to 50% of the SEAOC-recommended lateral force. Comparable performance is achieved for the base-isolated moment frame at various design force levels, depending on the performance criteria.

122. Lin, A. N.; Shenton, H. W., III; Lew, H. S.
Relative Performance of Fixed and Isolated Structures.
National Institute of Standards and Technology, Gaithersburg, MD
World Conference on Earthquake Engineering, 10th. July 19-24, 1992, Madrid, Spain,
A. A. Balkema/Rotterdam/Brookfield, 2485-2490 pp, 1992.

structures; earthquakes; statistical analysis; time histories; frame designs; steel moment frame; concrete moment frame

Base isolation has yet to receive widespread acceptance and implementation in the design of non-critical facilities. One reason for this is the lack of equivalent performance/cost comparison data for base-isolated and fixed-base structures. Presented are the results of an investigation in which the performance of several fixed-base and base-isolated structures were compared. Four-story, steel and concrete moment resisting frames were designed in accordance with the 1990 Structural Engineers Association of California recommended provisions. The base-isolated structures were designed to varying fractions of the recommended lateral force. Non-linear time history analyses were conducted for an ensemble of recorded earthquakes. Statistical analysis of peak response quantities demonstrates the superior performance of the isolated structures. Results illustrate that comparable performance is generally achieved when the isolated frames are designed to between 25% and 50% of the recommended lateral force.

123. Lin, C.; Nguyen, T.; McKnight, M. E.
Relation Between AC Impedance Data and Degradation of Coated Steel. 1. Effects of Surface Roughness and Contamination on the Corrosion Behavior of Epoxy-Coated Steel.
National Institute of Standards and Technology, Gaithersburg, MD
Progress in Organic Coatings, Vol. 20, 169-186, 1992.

steels; degradation; contamination; corrosion; surface roughness; coatings

The effects of surface roughness and inorganic chloride contamination on the corrosion behavior of steel coated with thin, amine-cured epoxy films have been investigated using AC impedance spectroscopy. The results were analyzed using the equivalent circuit models to identify the different steps in the corrosion of coated steel. Two types of corrosion were observed depending on the surface treatment: point-attack corrosion for uncontaminated and blistered corrosion for contaminated surfaces. Both types of corrosion can be discerned by AC impedance spectroscopy and modeled by the equivalent circuits. Coating-deficient areas at the peaks of sandblasted substrate have been calculated accurately from the AC impedance data and verified by scanning electron microscopy.

124. Liu, S. T.; Kelly, G. E.; Terlizzi, C. P.
Evaluating the Off-Cycle Losses of a Gas-Fired, Power Vented Furnace Employing Post Purge.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4908;   30 p. August 1992.
Available from National Technical Information Services
PB92-238567

ANSI/AHSRAE 103; burner off-cycle; calculation procedure; DOE test procedure; furnace/boiler test; off-cycle loss; performance test; post purge; power-vented burner; tracer gas test

A gas-fired, induced draft furnace employing post purge for venting after the burner shut off was tested by using a continuous tracer gas measurement technique over the entire off-cycle to determine the off-cycle sensible loss for various durations of post-purge.   The results were compared with those obtained by the existing optional tracer gas method described in ANSI/ASHRAE Standard 103-1988. The existing optional tracer gas procedure uses tracer gas data obtained at one prescribed time in the off-cycle along with an analytical procedure to calculate the loss. This optional procedure

was found to under-estimate the off-cycle loss and to give significant error with longer post purge durations. A new analytical procedure was developed to correct the deficiency in the existing procedure. The new procedure divides the off-cycle period into two intervals. The loss during the purging interval was calculated analytically by assuming a linear variation of the flue gas temperature and a constant volumetric flow rate of the flue gas. The loss during the interval after post-purge was calculated by the existing optional tracer gas procedure where the prescribed time to measure the one point tracer gas data was delayed by the length of the post-purge interval. The total off-cycle loss calculated by the new procedure gave reasonably good agreement with the integrated results from the continuous tracer gas measurement technique over the entire off-cycle. The new procedure is simpler to apply tan the one using the continuous tracer gas measurement and requires only a small increase in the data taking effort and some minor revision of the existing test and calculation procedures.

125. Loh, H. T.
Concurrent Flow Flame Spread Study.
California Univ., Berkeley
NIST-GCR-92-603;   161 p. March 1992.
Available from National Technical Information Services
        flame spread; oxygen concentration; paper; plastics; polymethylmethacrylate
An experimental study has been performed of the spread of flames over the surface of thick PMMA and thin filter paper sheets in a forced gaseous flow of varied oxygen concentration moving in the direction of flame spread. It is found that the rate of spread of the PMMA pyrolysis front is time independent, linearly dependent on the gas flow velocity and approximately square power dependent on the oxygen concentration of the gas. The experimental data with thin filter paper sheets shows that the flame spread rate is independent of the flow velocity for forced flow conditions and linearly dependent on the oxygen concentration of the flow. In both experiments, it was found that the flame spread rate data can be correlated in terms of parameters deduced from heat transfer considerations only. This indicates that heat transfer from the flame to the condensed fuel is the primary mechanism controlling the spread of flame. Finite rate chemical kinetic effects have apparently a small influence on the flame spread process itself. Analytical and numerical methods were also employed to study theoretically the flame spread process over thermally thick fuel and the influence on the flow field behavior in the presence of a flame. It is found that an analytical model based on a quasi-steady analysis and the flame sheet approximation predicts a square power law dependence of the flame spread rate on the flow oxygen concentration and a linear dependence on the flow velocity. The correct and encouraging qualitative descriptions of the flow structure and surface fluxes in the region downstream from the pyrolysis front.

126. Madrzykowski, D.; Evans, D. D.; Haynes, G. A.
Engineering Analysis of the Kuwait Oil Fires.
National Institute of Standards and Technology, Gaithersburg, MD
Maryland Univ., College Park
Society of Fire Protection Engineers. Large Fires: Causes and Consequences. Extended Abstracts. SFPE Engineering Seminars. November 16-18, 1992, Dallas, TX. Society of Fire Protection Engineers, Boston, MA 40-47 pp, 1992.
        well fires; heat release rate; flame height; thermal radiation
A series of measurements were made in the Al Mawqa/Al Ahmadi oil field region of Kuwait to explore the feasibility of assessing the heat release rate of individual well fires through flame height and thermal radiation measurements. The 12 fires measured ranged in calculated heat release rate from 90 to 2000 MW which correspond to flow rates of 240 m^3/day (1500 bbl/day) to 4800 m^3/day (30,000 bbl/day). Based on these 12 burning well measurements, the estimated total flow from the 651 damaged wells, both burning and leaking in March 1991, was 7,400,000 bbl/day which is only 20 percent greater than published NOAA estimates based on information from the Kuwait Oil Company.

127. Madrzykowski, D.; Vettori, R. L.
Sprinkler Fire Suppression Algorithm.
National Institute of Standards and Technology, Gaithersburg, MD
General Services Administration, Washington, DC

Journal of Fire Protection Engineering, Vol. 4, No. 4, 151-164, 1992.

> sprinklers; fire suppression; crib fires; fire tests; heat release rate; office furniture

A study was conducted to develop a sprinkler fire suppression algorithm for use with sprinkler activation time models. Large-scale experiments were performed to determine the heat release rate (HRR) of selected office fuel packages with and without sprinklers operating. Eight different fuel packages were evaluated. The results from these experiments were used to develop a time dependent HRR reduction factor.

128.   Madrzykowski, D.; Vettori, R. L.
        Sprinkler Fire Suppression Algorithm for the GSA Engineering Fire Assessment System.
        National Institute of Standards and Technology, Gaithersburg, MD
        General Services Administration, Washington, DC
        NISTIR 4833;   41 p. May 1992.
        Available from National Technical Information Services
        PB92-187145

> sprinklers; fire suppression; crib fires; fire tests; fuel load; heat release rate; office furniture

A study was conducted to develop a sprinkler fire suppression algorithm for use with sprinkler activation time models. Large scale experiments were performed to determine the heat release rate (HRR) of selected office fuel packages with and without sprinklers operating. Eight different fuel packages were evaluated. The results from these experiments were used to develop a time dependent HRR reduction factor. The sprinkler fire suppression algorithm consists of multiplying the HRR reduction factor by the HRR at the time of sprinkler activation yielding an expected upper bound to the HRR at a given time after sprinkler activation, $Q(t)$, for office furnishing fires that are not heavily shielded. This sprinkler fire suppression algorithm can be thought of as a "zeroth order" fire suppression model for "light hazard" occupancies with a sprinkler spray density of 0.07 mm/s (0.1 gpm/ft^2) or greater.

129.   Marshall, R. D.
        Some Notable Hurricanes Revisited.
        National Institute of Standards and Technology, Gaithersburg, MD
        American Society of Civil Engineers (ASCE) Structures Congress. April 1992, San Antonio, TX, 250-253 pp, 1992.

> hurricanes; field measurements; gust factors; disasters; structural engineering; tropical cyclones; wind damage; wind engineering; wind velocity

Recorded hurricane wind speeds, uncorrected for instrument height, averaging time or local wind exposure, can be very misleading. This is particularly true when such records are used to assess the performance of structures exposed to extreme winds. Only when proper corrections are applied can the true distribution of surface wind speeds in a hurricane be ascertained. Recent improvements to adjustment procedures and resulting corrections to wind speed records from some notable hurricanes are described.

130.   Marshall, R. D.; Phan, L. T.; Celebi, M.
        Measurement of Structural Response Characteristics of Full-Scale Buildings: Comparison of Results From Strong-Motion and Ambient Vibration Records.
        National Institute of Standards and Technology, Gaithersburg, MD
        Geological Survey, Menlo Park, CA
        NISTIR 4884;   85 p. October 1992.
        Available from National Technical Information Services
        PB93-113579

> buildings; damping; earthquakes; instrumentation; dynamic response; field measurements; signal processing; structural dynamics

This report describes the collection and analysis of ambient vibration data from five buildings in the San Francisco Bay area that experienced strong shaking during the Loma Prieta earthquake of October 17, 1989. The buildings represent a range of construction materials, structural systems, foundation systems and building dimensions. Results of the analyses are compared with similar analyses carried out on strong-motion response records obtained from the same buildings during the earthquake. While the lower modes of vibration can be reliably identified from ambient vibration records, the frequencies of these modes are in each case higher than the corresponding frequencies derived from strong-motion

response records. When soil-structure interaction is involved, the strong-motion model frequencies may range from 70 to 80 percent of the corresponding values extracted from ambient vibration records. Estimates of structural damping derived from ambient vibration data are substantially smaller than those derived from strong-motion data and are consistent with predictions of a damping model based on forced vibration tests. The lower bound of damping estimates obtained from strong-motion response records in this study is consistent with published data. Where soil-structure interaction is a significant factor, the overall damping for strong-motion response may be 3 to 4 times the indicated lower bound.

131. Martys, N.; Garboczi, E. J.
Length Scales Relating the Fluid Permeability and Electrical Conductivity in Random Two-Dimensional Model Porous Media.
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review B., Vol. 46, No. 10, 6080-6090, September 1, 1992.

permeability; electrical resistivity; porous media; structural models; algorithms; length scales; random systems; fluid flow

We present results of a study testing proposed length scales relating the bulk electrical conductivity of a fluid-saturated porous medium to its permeability. We also examine differences between the electric fields and the fluid-flow fields for a given pore structure by comparing their respective two-point correlation functions. The length scale is analytically related to an electric-field correlation length, and is found, to a good approximation, to be proportional to a fluid-velocity correlation length. The results of this paper demonstrate the important effect that spatial randomness in the pore space has on flow problems. In a random pore structure, with a distribution of pore sizes, the flow will tend to go more through the largest pore necks, decreasing the importance of the narrowest necks that tend to dominate the behavior of periodic models.

132. Matsushita, T.; Klote, J. H.
Smoke Movement in a Corridor: Hybrid Model, Simple Model and Comparison With Experiments.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4982;   51 p. December 1992.
Available from National Technical Information Services
PB93-146678

corridors; smoke movement; comparison; heat transfer; large scale fire tests

A hybrid model for modeling smoke movement in a corridor is described. This model uses a new approach for determining the corridor smoke flow. The hybrid model is a two zone model which considers velocities in each zone, and uses a fine mesh to the direction of propagation. Two different approaches to deal with the pressure term are addressed. Full scale and reduced scale experiments are described and compared with the results of the hybrid model. Since heat transfer is not presently incorporated in the hybrid model, the simulated velocity of spread is constant. But in the experiment, the velocity drops with advancing time. A simple model with heat transfer is also described. This model is similar to the density flow model, and assumes that the movement of the smoke front (nose) is similar to the flow through vertical openings in a zone model. Results of the simple model are compared with the experiment with heat transfer, and the effect of the heat transfer coefficient is observed.

133. McCaffrey, B. J.; Tu, K. M.; Rinkinen, W. J.; Eklund, T. I.
Model Study of the Aircraft Cabin Environment Resulting From In-Flight Fires.
Maryland Univ., College Park
National Institute of Standards and Technology, Gaithersburg, MD
Federal Aviation Administration, Atlantic City International Airport, NJ
 DOT/FAA/CT-90/22;   126 p. November 1992.

aircraft compartments; in-flight fires; heat transfer; scale models; simulation; ventilation

A series of tests were conducted to examine the effect of the ventilation on the environment in an aircraft passenger cabin during an in-flight fire. These tests were run in a reduced scale mockup of an aircraft passenger cabin. A propane burner operating at 10 or 30 kilowatts served as the fire source. The simulated seats and the cabin lining material were both

noncombustible. The vertical temperature and gas concentration profiles in the cabin were measured as a function of time. Reversing the normal ventilation flow direction by introducing the forced air at the floor level and exhausting it at the ceiling significantly reduced the measured temperatures and gas concentrations. Opening two 152-by 305-millimeter hatches in the end walls at the ceiling level to the outside air resulted in a significant reduction in the measured gas concentrations.

134. McKnight, M. E.; Roberts, W. E.
Lead Concentration in Consumer Paints: A Pilot Study.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4851; 14 p. June 1992.
Available from National Technical Information Services
PB92-213370

paints; lead (metal); consumer paint; lead concentration; x-ray fluorescence spectrometry
A pilot study was conducted for the U. S. Department of Housing and Urban Development (HUD) to measure the lead concentrations in a small sampling of new consumer paints. Although a Consumer Product Safety Commission Regulation requires that the lead concentration be no greater than 0.06 percent (600 parts per million, ppm or 600 mu g/g) by mass of paint solids, the actual lead concentration is not usually measured and reported. Estimates of expected lead concentrations in new paint are needed in HUD's lead-paint abatement program. Thus, the objective of this pilot study was to determine whether the lead concentration in a small sampling of new paints tended to be near the regulatory limit. The lead concentration in each of 31 consumer paints was measured using laboratory x-ray fluorescence spectrometry. All concentration estimates were less than 100 ppm. The lead concentration of most samples was below the detection limit of the procedure used of 30 ppm.

135. Mitler, H. E.; Walton, G.
Computer Model of the Smoldering Ignition of Furniture.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4973; 100 p. November 1992.
Available from National Technical Information Services
PB93-125060

furniture; smoldering; ignition; computer models; mathematical models; pyrolysis
This paper describes a user-friendly computer model, TMPSUB2. This model calculates the temperature field throughout a solid (but porous) substrate which can undergo exothermic pyrolysis, when it is exposed to an arbitrary (localized) heat flux which can move uniformly, such as that of a smoldering cigarette. TMPSUB2 has successfully simulated the thermal runaway signifying smoldering ignition of the substrate when it is exposed to a set of external heating fluxes. The processes taken into consideration are three-dimensional heat conduction in the substrate, pyrolysis of the latter, and the diffusion of air into it at the top surface. TMPSUB2 also takes into account the fact that the substrate consists of two layers (a foam pad covered by a fabric), with the possibility of an air gap between them, up to three pyrolytic reaction steps, and with temperature-dependent thermophysical constants. TMPSUB2 solves the equations describing the physics and chemistry of the heating and ignition process numerically; the results have been compared with a set of ignition experiments, and have been found to be semi-quantitatively correct, both for the ignition temperature and for the time to ignition. Analysis of the experiments indicates that the substrate, which consists of a thin fabric layer over a thick foam padding, behaves as a thermally thin layer. Use of TMPSUB2 shows that smoldering ignition would result from a stationary hot spot of intensity and dimension simulating a quietly smoldering cigarette. A users' guide is included.

136. Moss, W. F.
Numerical Analysis Support for Compartment Fire Modeling and Incorporation of Heat Conduction Into a Zone Fire Model. Final Report. August 15, 1988-March 31, 1991.
Clemson Univ., SC
NIST-GCR-92-605; 50 p. March 1992.
Available from National Technical Information Services

fire models; zone models; numerical analysis; conductive heat transfer; computer modeling; fire modeling

This report summarizes numerical fire modeling research conducted for NIST Grant Number 60NANB8D0857 from August 15, 1988 to March 31, 1991. The research goal for the first year of the grant was to determine the best available numerical technology for use in zone fire modeling. The goal for the second year was to incorporate heat conduction into a zone fire model in a numerically robust and efficient manner. Three prototype zone fire models named MCCFM, CONRAD1 and CONRAD2 were constructed to test the numerical technology used to realize these goals. These zone fire models and their implementations as Fortran codes are presented. The code MCCFM, developed during the first year of the grant, demonstrates the advantages of using mass as a solution variable instead of density. CONRAD1 and CONRAD2 examine two strategies for coupling the heat conduction equation (a one dimensional partial differential equation) with the zone fire modeling ordinary differential equations. CONRAD1 performs this coupling via the method of lines by using standard piecewise cubic Hermite polynomial basis functions to represent the unknown temperature profiles in the ceiling, wall, and floor heat conduction nodes. CONRAD2 reduces the heat conduction problem to a set of implicitly defined functional equations, a strategy never before used in zone fire modeling. Both CONRAD1 and CONRAD2 use a differential-algebraic equation solver. Supporting numerical results are presented with timings for a Sun Sparcstation 2.

137.   Moss, W. F.; Forney, G. P.
         Implicitly Coupling Heat Conduction Into a Zone Fire Model.
         Clemson Univ., SC
         National Institute of Standards and Technology, Gaithersburg, MD
         NISTIR 4886;   34 p. July 1992.
         Available from National Technical Information Services
         PB92-222769
                  conductive heat transfer; fire models; zone models; equations; computer models; algorithms
         This report examines several methods for coupling the partial differential equations that arise in conductive heat transfer with the ordinary differential equations that arise in zone fire modeling. Two existing algorithms (method of lines and time splitting) are discussed and a new strategy is proposed for performing this coupling. This strategy couples the wall surface temperature rather than the entire wall temperature profile with the other zone fire modeling solution variables by requiring that the wall surface temperature gradient and the incident heat flux (sum of convective and net radiative flux) satisfy Fourier's law. Two prototype fire models were written to test the ideas discussed in this report. The first, CONRAD1, implements the method of lines strategy for solving heat conduction. The second, CONRAD2, implements the new strategy. Though inefficient, CONRAD1 uses will established numerical techniques and therefore serves as a benchmark to test the numerical ideas implemented in CONRAD2. Both programs use the stiff differential-algebraic equation solver DASSL. Supporting numerical results are presented.

138.   Motevalli, V.; Ricciuti, C.
         Characterization of the Confined Ceiling Jet in the Presence of an Upper Layer in
         Transient and Steady-State Conditions. Final Report. August 1990-July 1991.
         Worcester Polytechnic Inst., MA
         NIST-GCR-92-613;   151 p. August 1992.
         Available from National Technical Information Services
         PB92-238690
                  ceiling jets; ceilings; fire plumes; heat transfer; temperature; walls
         Although both confined and unconfined smooth ceiling jets have been previously studied, the data from small-scale experiments evaluated in this report provided a unique opportunity to characterize the transience of a ceiling jet in the presence of a developing upper layer. The development of an upper layer in an enclosure fire has notable effects on the ceiling jet. The presence of this hot gas layer increases the temperature in the ceiling jet and the heat transfer to the ceiling. Accurate prediction of the characteristics of the confined ceiling jet is important in calculating the response time of detection and suppression devices. This report examines data from a study of small-scale fire induced ceiling jet in a confined situation for a smooth horizontal ceiling. These results were obtained from experiments conducted at the National Institute of Standards and Technology, Center for Fire Research using 2.0 and 0.75 kW fires at r/H locations of 0.26 and 0.75. The data gathered from these experiments represents a collection of transient and steady-state temperature and velocity measurements of a confined ceiling jet and upper layer. The results from this data were compared to similar experimental data collected in a previous study for unconfined ceiling jet using the same apparatus.

Comparison of the confined and unconfined ceiling jet data, quantification of the developing upper layer and analysis of heat transfer to the ceiling, are presented in this report. Despite the limited data, it is concluded that the unconfined ceiling jet correlations may only be valid at the very early time, prior to development of the upper layer and that steady-state unconfined correlations are certainly invalid for confined conditions. The velocity of the confined ceiling jet within the upper layer is 20-25% less than the unconfined case affecting the heat transfer coefficient. The heat transfer analysis showed that values of 4-5 W/m2 deg C can be expected.

139. National Conference of States on Building Codes and Standards; National Institute of Standards and Technology
Seismic Provisions of State and Local Building Codes and Their Enforcement.
National Conference of States on Building Codes and Standards, Herndon, VA
National Institute of Standards and Technology, Gaithersburg, MD
NIST-GCR-91-599; 366 p. May 1992.
Available from National Technical Information Services
PB92-196062

> building codes; building design; building construction; safety; code enforcement; Executive Order; Federal agencies; local jurisdiction; seismic safety; states

The purpose of this report is to provide information on the status of building codes with seismic design and construction provisions adopted by state and local jurisdictions. It also provides information on the enforcement of these provisions. Building code adoption and enforcement data is included for 50 states, three U. S. territories, 186 of the largest local jurisdictions (all cities over 100,000 in population), and 1,164 other units of local government (county/city). This report, along with another report "Assessment of the Seismic Provisions of the Model Building Codes, " NIST-GCR-91-598, has been prepared to assist Federal agencies in evaluating the adequacy of local codes in content and enforcement. Such evaluations are required in order to implement Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction."

140. Nelson, H. E.; Deal, S.
CORRIDOR: A Routine for Estimating the Initial Wave Front Resulting From High Temperature Fire Exposure to a Corridor.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4869; 39 p. July 1992.
Available from National Technical Information Services
PB92-213347

> corridors; compartment fires; computer programs; fire models; flashover; gas composition; gravity; heat loss; room fires; smoke movement

A first order model and computer program implementing previously developed procedures for estimating the speed, depth, and temperature of a fire produced gravity wave front in a corridor have been developed. The program has been incorporated into FPETOOL and adjustments made to accommodated fires that occur in the corridor or in a room adjacent to the corridor. Comparisons to test results are presented and show reasonable correlation. A users' guide is included.

141. Notarianni, K. A.
Predicting the Response of Sprinklers and Detectors in Large Spaces.
National Institute of Standards and Technology, Gaithersburg, MD
General Services Administration, Washington, DC
Society of Fire Protection Engineers. Large Fires: Causes and Consequences. Extended Abstracts. SFPE Engineering Seminars. November 16-18, 1992, Dallas, TX. Society of Fire Protection Engineers, Boston, MA 23-28 pp, 1992.

> sprinklers; aircraft hangars; fire tests; temperature measurements; fire models

Measurements made during fire tests conducted in an aircraft hangar with a ceiling height of 30.4 m are presented. Five gas temperatures and disk temperatures were measured above the fire and along the ceiling in locations corresponding

to the expected location of sprinklers or detectors. Measurements were designed utilizing the computer fire models FPETOOL, DETACT-QS, and LAVENT. The results of the fire experiments were then compared to the predictions from the computer models in order to determine the limits of applicability of the models and to develop recommendations for use in large spaces. In the analysis conducted, computer fire models undepredicted the ceiling jet temperatures and thus would be conservative in their activation predictions. For large spaces, a model should be developed that includes hot gas transport time and fire plume dynamics.

142.   Nguyen, T.
        Thermal-Wave Microscopy in Corrosion Studies.
        National Institute of Standards and Technology, Gaithersburg, MD
        Materials Characterization, Vol. 28, 291-309, 1992.

corrosion; microscopy; steels; humidity; water; coatings; quantitative analysis

All forms of metallic corrosion cost the United States 4.3% of its gross national product, about $175 billion per year at the present value. Corrosion costs may be reduced by understanding how and why corrosion occurs and then by changing the conditions that promote it. The most commonly used microscopical techniques to detect and characterize early corrosion of metals have been scanning electron and light microscopies. A body of information has been accumulated in the past several years demonstrating that a new technique, thermal-wave microscopy (TWM), has considerable promise as a nondestructive tool for obtaining information on a micrometer scale about the surface and near-surface features of transparent and opaque materials. The technique, which is sensitive to minor variations in the thermal conductivity of materials (such as those caused by grain boundaries, deformed structures, and defects), can potentially image the microstructure and corrosion products of metal with and without a coating. We have applied TWM using an electron beam as the thermal excitation source [electron thermal-wave microscopy (ETWM)] to study corrosion of bare steel and also of steel under organic protective coatings. This article presents the results of these studies. Because the images resulting from TWM appear dramatically different from those obtained by light or scanning electron microscopy, and because the use of TWM has been limited primarily to the semiconductor industry, a brief summary of the principle and its current applications in material science is presented in the following section.

143.   Nguyen, T.; Byrd, E.; Bentz, D.
        In Situ Measurement of Water at the Asphalt/Siliceous Aggregate Interface.
        National Institute of Standards and Technology, Gaithersburg, MD
        American Chemical Society (ACS). Fuel Division Proceedings. August 1992, 1992.

water; asphalt; aggregates; spectroscopy

Water at the asphalt/aggregate interface is the major contributor to the debonding of asphalt from mineral aggregates (stripping). This paper describes a spectroscopic technique to detect and measure in situ water at the interface between an asphalt and a siliceous aggregate, and the application of the technique to studies of several asphalts. The technique employs Fourier transform infrared (FTIR) spectroscopy in the multiple internal reflection (MIR) mode. An asphalt layer of any thickness is coated on an SiO2-covered Si internal reflection element (IRE) and a water chamber is attached to the asphalt-coated substrate. Spectra are taken automatically at specified time intervals without disturbance of the specimens. In the study, water at the asphalt-aggregate interface for five Strategic Highway Research Program (SHRP) core asphalts (ACC-1, AAD-1, AAG-1, AAK-1 and AAM-1) of about 60 mum thick on an SiO2-Si substrate was measured using the technique. The amount and thickness of the water layer at the asphalt/siliceous aggregate interface were determined based on internal reflection spectroscopy theory, the water concentration-intensity calibration curve obtained using a series of H20/D20 mixtures, and the water uptake of the asphalts. The results indicated that the thickness of the water layer at the asphalt/siliceous aggregate interface increased as time of exposure increased. Water adsorption characteristics at the asphalt/SiO2-Si substrate interface were different for the five asphalts. The technique should be useful for evaluating asphalt-siliceous aggregate mixtures in terms of water diffusion, water susceptibility, effectiveness of antistripping agents, and effects of aggregate surface contamination on water stripping.

144.   Nguyen, T.; Byrd, E.; Bentz, D.
        Quantifying Water at the Coating/Substrate Interface.
        National Institute of Standards and Technology, Gaithersburg, MD
        American Chemical Society (ACS). Phase Division Proceedings. Volume 66. April 1992, 414-415 pp, 1992.

water; substrates; coatings; blistering; delamination; corrosion

Water at the polymer coating/substrate interface causes degradation of polymer coated materials. The most visible effects are blistering and delamination when polymer coated materials are exposed to high relative humidities or immersed in aqueous solutions. For metal substrates, water is also one of the main ingredients necessary for corrosion reactions to occur. Further, the presence of a water layer at the coating/metal interface is essential for the corrosion process to spread. Measurement of water at the polymer coating/substrate interface is the subject of great interest in many industries such as organic coatings, electronic packaging, and asphalt pavements. In previous publications, we reported the development of a technique based on Fourier transform infrared - multiple internal reflection (FTIR-MIR) spectroscopy for studying in situ water at the polymer/metal interface. In this paper, we describe the use of this technique to quantify the water layer at the polymer coating/substrate interface. Quantitative information on water at the coating/substrate interface will enhance our understanding of the controlling factors in and the mechanisms of blistering, delamination, and corrosion of polymer coated materials.

145.   Nguyen, T.; Byrd, W. E.; Bentz, D.; Seiler, J., Jr.
Development of a Technique for In Situ Measurement of Water at the Asphalt/Model Siliceous Aggregate Interface.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4783;   62 p. March 1992.
Available from National Technical Information Services

aggregates; water; asphalt; spectroscopy; bonding; diffusion; FT-IR; asphalt; asphalt/aggregate interface; in situ measurement; water absorption; water susceptibility

A technique based on Fourier transform infrared (FTIR) spectroscopy in the multiple internal reflection (MIR) mode was developed for measuring water in situ at the interface between an asphalt and a model siliceous aggregate. The technique required the coating of an asphalt layer of known thickness on an internal reflection element (IRE), which served as an optical guide to obtain an infrared spectrum. A water chamber was attached to the asphalt-coated IRE, and FTIR-MIR spectra were taken automatically at specified times without disturbance of the specimens. In situ water measurements for five Strategic Highway Research Program (SHRP) core asphalts (AAC-1, AAD-1, AAG-1, AAK-1 and AAM-1) on a hydrated, SiO_2-covered Si IRE, which served as the model siliceous aggregate, were carried out using the technique. An FTIR-MIR study of water at different concentrations and experiments on water absorption in SHRP asphalts were also done for the quantitative analysis. Calculations were made to demonstrate that the water detected was at or near the asphalt/siliceous aggregate interface. The results have shown that the technique can detect and quantify water in situ at the asphalt/siliceous interface, and provide unique information on the transport properties of water through an asphalt layer attached to a substrate. The technique developed here should be useful for evaluating asphalt/siliceous model aggregate mixtures in terms of 1) water susceptibility of an asphalt/aggregate mixture, 2) effectiveness of antistripping agents, 3) effects of aggregate surface contamination and environmental temperature on water stripping, and 4) water diffusion through asphalts on an aggregate. The technique should also be effective in obtaining quantitative information on the transport of water and other compounds, both organic and inorganic, through a layer of any thickness of asphalt/aggregate mixture, cement, and concrete attached to a substrate. Results of an exploratory test method for measuring the bond strength of an asphalt on an aggregate in the presence of water are given.

146.   Nguyen, T.; Hubbard, J. B.; Pommersheim, J.
Mathematical Model for the Degradation on Intact Coatings on Steel Exposed to Electrolyte Solutions.
National Institute of Standards and Technology, Gaithersburg, MD
American Chemical Society. Volume 67. August 1992, Washington, DC, 71-73 pp, 1992.

steels; mathematical models; degradation; protective coatings; blistering; diffusive transport

Organic coatings are the most widely used means of protecting metals against corrosion. Despite improvements in coating technologies, problems continue to exist in protecting metals from their environments. Considerable research on the degradation of coated metals has ben done and significant advances in understanding the mechanisms and mode of failure of these materials when exposed to a corrosive environment have been made. However, there has been little work to quantitatively describe the degradation and predict the performance of a coating/metal system during service. This paper presents two mathematical models which have been developed to describe the degradation of an intact coating on a steel substrate exposed to an electrolytic environment. This paper is a contribution from NIST to honor Dr. Ray Dickie for

his outstanding research on protective coatings and his significant contribution to the understanding of the degradation or organic protected metals.

147.   Nyden, M. R.; Brown, J. E.; Lomakin, S. M.
        Molecular Dynamics Modeling of Polymer Flammability.
        National Institute of Standards and Technology, Gaithersburg, MD
        Materials Research Society. Materials Research Society Symposium Proceeding Volume 278.
        Spring Meeting. April 27-May 1, 1992, San Francisco, CA, 47-53 pp, 1992.

    flammability; simulations; char formation; thermal degradation; computer models; crosslinking; equations
    Molecular dynamic simulations were used to identify factors which promote char formation during the thermal degradation of polymers. Computer movies based on these simulations, indicate that cross-linked model polymers tend to undergo further cross-linking when burned, eventually forming a high molecular weight, thermally stable char. This prediction was confirmed by char yield measurements made on gamma and e- irradiated polyethylene and chemically cross-linked poly(methyl methacrylate).

148.   Nyden, M. R.; Forney, G. P.; Brown, J. E.
        Molecular Modeling of Polymer Flammability: Application to the Design of Flame-Resistant Polyethylene.
        National Institute of Standards and Technology, Gaithersburg, MD
        Macromolecules, Vol. 25, No. 6, 1658-1666, 1992.

    polyethylene; flammability; thermal degradation; char; crosslinking; molecular weight; simulation; validation
    Molecular dynamic simulations of the thermal degradation of polyethylene were used to identify factors which might be effective in reducing polymer flammability by promoting the formation of a residual char. Computer movies of the calculated trajectories indicate that cross-linked polymers, such as those obtained from exposure of polyethylene to ionizing radiation, will undergo further cross-linking when burned, eventually forming a high molecular weight, thermally stable char. This prediction was confirmed in flammability tests of gamma-ray-irradiated polyethylene.

149.   Odler, I.; Stutzman, P.
        Texture of Mature Tricalcium Silicate and Portland Cement Pastes as Studied by Scanning Electron Microscopy.
        Technical Univ., Clausthal, Germany
        National Institute of Standards and Technology, Gaithersburg, MD
        International Cement Microscopy Association. International Conference on Cement Microscopy, 14th. April 5-9, 1992, Costa Mesa, CA, Intl. Cement Microscopy Assoc., Duncanville, TX, Gouda,G. R.; Nisperos, A.; Bayles, J., Editors, 449-461 pp, 1992.

    microscopy; silicate; portland cement; pastes; x-ray imaging; electron imaging; fracture surfaces; polished sections
    Mature tricalcium silicate and portland cement pastes were studied by scanning electron microscopy with backscattered electron and x-ray imaging. Distinct differences in paste microstructure were observed in both tricalcium silicate and portland cement pastes with different water-solid ratios and hydration temperatures. In contrast, few differences were observed in microstructures of C3S and portland cement pastes at equal water-solids ratios. X-ray imaging showed the individual elements within the paste to be unevenly distributed.

150.   Ohlemiller, T. J.
        Assessment of the NASA Flammability Screening Test and Related Aspects of Material Flammability. Final Report. July 1989-June 1992.
        National Institute of Standards and Technology, Gaithersburg, MD
        NISTIR 4882; NASA CR-189226;   45 p. August 1992.
        Available from National Technical Information Services
        PB92-238591

    flammability; fire safety; fire tests; flame spread; heat release rate; ignitability; microgravity; spacecraft fires
    This final report summarizes the results of an assessment of the NASA flammability screening test (8060.1B) for materials to be used in manned spacecraft interiors. A set of materials was examined using the standard NASA test, a modified

version of this test which incorporated external radiation and NIST tests which measure ignitability, rate of heat release and opposed flow flame spread behavior. Materials passing the standard NASA screening test showed widely varying degrees of flammability enhancement when subjected to external radiation (modified NASA test, NIST tests). Since such radiation is implicit in many normal fire scenarios, materials passing the standard NASA screening test should not be treated as non-flammable. The quantitative role of self-feedback of radiation remains to be fully clarified; an apparatus to examine this issue was built but no tests could be completed in the allotted time. The rate of heat release from the two-sided burning of thermally-thin materials was quantitatively compared to that for one-sided burning; this issue was believed to be at the heart of certain anomalies in the earlier stages of this study. A synegeristic enhancement of heat release rate was indeed found for two-sided burning of three materials two simplified models account for the origin of this effect. On the basis of this study, it is recommended that NASA supplement their existing flammability screening test with one that incorporates external radiation. It is further recommended that this supplemental test in normal gravity be correlated experimentally with a similar test in micro-gravity.

151.   Ohlemiller, T. J.; Villa, K. M.
Characterization of the California Technical Bulletin 133 Ignition Source and a Comparable Gas Burner.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 18, No. 4, 325-354, 1992.

> ignition source; gas burners; test methods; upholstery; newsprint; chairs; heat flux; simulation

The California (CB) Bulletin 133 upholstery ignition source is based on the use of crumpled newsprint. The present work examined the reproducibility of several aspects of this source when placed on an inert chair mock-up. The tendency of this source to heat the side arms of a chair, the area of the seat back subjected to high heat fluxes, the peak flux there and the flux duration all showed substantial variability. For inherently lesser variability a gas burner is preferred. A gas burner, derived from that developed at the British Fire Research Station, was shaped so as to deposit a similar pattern of heat to that of the CB 133 source. The two sources were tested for comparability both on chair mock-ups and on full-scale chairs made from a wide variety of materials. The results indicate that the gas burner, as used here, is a somewhat less severe ignition source than is the CB 133 igniter.

152.   Palmer, M. E.; Reed, K. A.
3D Piping IGES Application Protocol, Version 1.1.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4797;   283 p. March 1992.
Available from National Technical Information Services
PB92-187061

> application protocols; application validation; CAD data exchange; computer-aided design; data exchange standards; data translation quality assurance; data translators; IGES application protocols; information management; piping design; piping systems

The 3D Piping IGES Application Protocol (AP) specifies the mechanisms for defining and exchanging 3D piping system models in IGES format. The AP defines three-dimensional arrangement data of piping systems which includes definition data types of geometry (shape and location), connectivity, and material characteristics. The scope of this AP includes only piping system data and not drawings or internal details of equipment. The specified piping model is sufficiently detailed to support the fabrication and final assembly of a piping system. IGES is designed to support a broad range of applications and information, and it is recognized that few implementations will support all of the specification. An application protocol defines a logical subschema of the IGES specification, the usage of the subschema, and the necessary benchmarks for testing implementations. The 3D Piping IGES Application Protocol is the first IGES AP to be delivered to industry and is an important example for the development of STEP (Standard for the Exchange of Product Model Data) application protocols. This document replaces the 3D Piping IGES Application Protocol, Version 1.0.

153.   Pannock, J.; Didion, D. A.
Performance of Chlorine-Free Binary Zeotropic Refrigerant Mixtures in a Heat Pump.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4748;   87 p. December 1992.
Available from National Technical Information Services

PB92-14981

binary zeotropic mixtures; COP; performance advantage; R22; R23; R32; R125; R134a; R143a; R152a; test facility; volumetric capacity

The phase-out of the currently used refrigerants during the next decade requires fast and accurate methods to evaluate possible alternatives for the existing refrigerants. This report investigates possible replacement refrigerants for R22, where the replacements are binary zeotropic mixtures of the following hydrofluorocarbons (HFCs): R23, R32, R125, R134a, and R152a. The method, that was chosen, is based on three steps: (1) determining possible mixture components, (2) evaluating all fifteen possible mixtures using a simulation program developed by NIST and determining the best performing mixtures, (3) evaluating the best performing mixtures in a NIST build test facility. Following this path, two refrigerant mixtures, R32/R134a and R32/R152a were found to perform better than R22 with respect to COP and volumetric capacity for certain composition ranges. The used simulation model proved to be a very precise tool in finding possible replacement fluids and their possible performance advantages. The results give the confidence that this time saving combination of simulation and testing is a very powerful engineering tool.

154.   Parker, W. J.
Wood Materials. Part A. Prediction of the Heat Release Rate From Basic Measurements.
National Institute of Standards and Technology, Gaithersburg, MD
Heat Release in Fires, Chapter 11, Elsevier Applied Science, NY, Babrauskas, V.; Grayson, S. J., Editors, 333-356 pp, 1992.

heat release rate; fire protection engineering; wood; chemical composition; equations; experiments; cone calorimeters

A number of progressively advanced HHR calorimeters have been designed and put into use, as discussed in Chapter 2. All of these measure the HRR per unit area as a function of external radiant heat flux (or, in a few cases, as a function of an exposure fire defined by its temperature). The corresponding net heat transfer through the flaming surface as required by any of the room fire growth models is not measured in any of these calorimeters. The heat release rate curves as a function of time at a particular external radiant flux are in general different for different calorimeters because of the different conditions under which the data are obtained. The variables include orientation and specimen size which affect heat feedback from the flame, boundary conditions at the rear surface, piloting arrangements, whether based on enthalpy rise or oxygen consumption, etc. A heat release rate model would be valuable in the analysis of the heat release rate calorimeters and in the interpretation of their measurements as well as in providing submodels for room fire growth models. At the same time the heat release rate calorimeters can provide a proving ground for the heat release rate model.

155.   Persily, A.
Technics Envelope Design Guidelines for Federal Office Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
P/A Progressive Architecture, 39-45, March 1992.

office buildings; building design; thermal performance; weather effects; building construction; concretes; bricks; curtain walls; insulation; penetration; roofs; walls

Office building envelopes are generally successful in meeting structural, aesthetic, and thermal requirements. However, shortcomings in thermal performance do occur and affect energy consumption, the durability of envelope materials, thermal comfort, and indoor air quality. One study of eight Federal office buildings specifically designed to meet energy performance standards employes thermal envelope diagnostic techniques to identify specific thermal envelope defects and to quantify their impact on thermal performance. These defects included missing and misinstalled insulation, thermal bridges, and inadequate air barrier systems or no air barrier at all. Such defects are caused by designs that do not adequately account for heat, air, and moisture transmission, are difficult to construct, do not have sufficient durability to perform for a reasonable length of time, or cannot withstand wind pressures or differential movements of adjoining elements. Other thermal defects are caused by poor construction technique.

156.   Persily, A. K.; Dols, W. S.; Nabinger, S. J.
Environmental Evaluation of the Federal Records Center in Overland Missouri.

National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4883;   28 p. August 1992.
Available from National Technical Information Services
PB92-238575

carbon dioxide; carbon monoxide; formaldehyde; indoor air quality; office buildings; radon; ventilation

The National Institute of Standards and Technology (NIST) is studying the thermal and environmental performance of new federal office buildings for the Public Buildings Service of the General Services Administration (GSA). This project involves long-term performance monitoring starting before occupancy and extending into early occupancy in three new office buildings. The performance evaluation includes an assessment of the thermal integrity of the building envelope, long-term monitoring of ventilation system performance, and measurement of indoor levels of selected pollutants. This is the second report describing the study of the Federal Records Center in Overland Missouri, and this report presents measurement results from preoccupancy to full occupancy. Ventilation rates ranged from 0.3 to 2.6 air changes per hour (ach) with the minimum levels being below both the building design value of 0.8 ach and the recommended minimum in ASHRAE Standard 62-1989. The measured radon concentrations were 2 pCi/L or less on the sub-basement level, and less than or equal to 0.4 pCi/L on the other levels. Foraldehyde concentrations ranged from 0.03 to 0.07 ppm,. Daily peak levels of carbon dioxide in the building were typically between 500 and 800 ppm. Maximum carbon monoxide levels were typically on the order of 1 to 2 ppm, essentially tracking outdoor levels induced by automobile traffic. There have been some occasions of elevated carbon monoxide and carbon dioxide levels in the building associated with unexplained episodic increases in the outdoor levels.

157.   Phan, L. T; Hendrickson, E. M.; Marshall, R. D.
Measurement of Structural Response Characteristics of Full-Scale Buildings: Analytical
Modeling of the San Bruno Commercial Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4782;   50 p. March 1992.
Available from National Technical Information Services
PB92-17197

earthquakes; accelerations; ambient vibration; analytical modeling; autocorrelation; buildings; damping; Fourier spectrum; frequencies; instrumentation; Loma Prieta; measurement; model analysis; structural response; transient analysis

A 6-story commercial office building in San Bruno, California, which experienced the Loma Prieta earthquake of October 17, 1989 and sustained no visible damage, was subjected to ambient vibration tests in September 1990. Ambient vibration data were recorded from the 13 accelerometers installed prior to the Loma Prieta earthquake. Comparison of dynamic characteristics revealed that the first-mode response frequency deduced from the Loma Prieta records is significantly lower than that deduced from ambient vibration tests, and the damping ratio for strong motion is substantially higher than that obtained from ambient vibration. A computer model of the building was developed and applied using two different boundary conditions; fixed-base and spring-supported conditions. The fixed-base condition was used to simulate the building response to ambient vibration, and the spring-supported condition was used to incorporate soil-structure interaction and thus simulate realistic building response to the Loma Prieta earthquake. Results of analyses showed that the first-mode response frequencies for the two cases differ by essentially the same factor observed from measurements. This suggests that the difference in first-mode response frequencies between ambient vibration and strong motion in this building was due largely to soil-structure interaction.

158.   Phan, L. T; Marshall, R. D.; Celebi, M.
Response of Buildings to Ambient Vibration and the Loma Prieta Earthquake: A
Comparison.
National Institute of Standards and Technology, Gaithersburg, MD
U. S. Geological Survey, Menlo Park, CA
American Society of Civil Engineers. Structures Congress '92 Compact Papers. 10th
Structures Congress. April 13-15, 1992, San Antonio, TX, Am. Soc. of Civil Engineers, New
York, NY, Morgan, J., Editor, 583-586 pp, 1992.

earthquakes; vibration; structural stability; tests; response time

Structural response characteristics of five existing buildings in the San Francisco bay area, obtained from ambient vibration testing conducted after the Loma Prieta earthquake (LPE), are compared with the response characteristics observed during the LPE. The purpose is to provide an assessment of the applicability of ambient vibration testing as a means to obtain dynamic properties for use in earthquake design. The comparisons show that, for all five buildings, the response frequencies measured from ambient vibration testing are higher than those obtained from the LPE, and damping estimates computed from ambient vibration response records are smaller than those from the LPE response records.

159.   Pielert, J. H.
        ASCE 11: Standard Guideline for Structural Condition Assessment of Existing Buildings.
        National Institute of Standards and Technology, Gaithersburg, MD
        Structures Congress '92, American Soc. of Civil Engineers, New York, NY, 352-355 p., 1992.
                structural engineering; standards; civil engineering
        The American Society of Civil Engineers (ASCE) established a Standards Committee on the Structural Condition Assessment of Existing Buildings in 1982. This effort has culminated in publication of ASCE 11-90 "Standard Guideline for Structural Condition Assessment of Existing Buildings." This standard is discussed along with new activities undertaken by the committee concerning condition assessment of the building envelope and seismic rehabilitation of buildings.

160.   Pielert, J. H.; Kaetzel, L. J.
        Cement and Concrete Materials Databases and the Need for Quality Testing.
        National Institute of Standards and Technology, Gaithersburg, MD
        Materials Science of Concrete III, American Ceramic Soc., Westerville, OH, 337-358 p.,
        1992.
                cements; concretes; databases; tests; construction materials
        The purpose of this chapter is to discuss the general topic of cement and concrete materials databases with an emphasis on the quality of laboratory testing. Specific Items covered include databases and knowledge-based systems, quality in laboratory testing, database standards activities, sources of data on the performance of cement and concrete materials, and database development activities for construction materials.

161.   Pietrzak, L. M.; Dale, J. J.
        User's Guide for the Fire Demand Model: A Physically Based Computer Simulation of the
        Suppression of Post-Flashover Compartment Fires.
        Mission Research Corp., Santa Barbara, CA
        NIST-GCR-92-612; MRC-R-1364; 79 p. July 1992
        Available from National Technical Information Services
        PB92-222736
                compartment fires; computer models; char; charring; drop sizes; droplets; extinguishment; flow rate; fire
                suppression; water sprays
        The Swedish Fire Research Board and the U. S. Federal Emergency Management Agency, with the cooperation of the U. S. National Institute of Science and Technology, supported the development of a computerized Fire Demand Model (FDM). The FDM simulates the suppression of post-flashover charring and non-charring solid fuel fires in compartments using water sprays from portable hose-nozzle equipment used by fire departments. The output of the FDM shows the extinguishing effects of water sprays at various flow rates and droplet sizes The calculations are based on a heat and mass balance accounting for gas and surface cooling, steam-induced smothering, direct extinguishment of the fuel and water spray induced air inflow and venting of heat and products of combustion. This document provides instruction on how to execute the FDM on a Personal Computer (PC). This includes a description of the required input parameters and instructions for producing three different types of graphical plots: (1) time-temperature histories, (2) volume-median-drop-size verses water application rate defining combinations where fire control is and is not possible, and (3) cross plots to facilitate comparison between different cases.

162.   Pimienta, P. J. P.; Garboczi, E. J.; Carter, W. C.
        Cellular Automation Algorithm for Surface Mass Transport Due to Curvature Gradients:

Simulations of Sintering.
National Institute of Standards and Technology, Gaithersburg, MD
Computational Materials Science, Vol. 1, 63-77, 1992.

algorithms; mass transport; gradients; simulation; microstructural development; sintering

A cellular automation algorithm is developed that simulates the evolution of a surface due to surface mass transport. The driving force is the reduction of chemical potential differences on the surface. This process is important in the development of microstructure during the sintering of powders. The algorithm is implemented in 2D in a digital image mode, using discrete pixels to represent continuum objects. The heart of the algorithm is a pixel-counting-based method for computing the potential at a pixel located in a digital surface. This method gives an approximate measure of the curvature at the given surface pixel. The continuum version of this method is analytically shown to give the true curvature at a point on a continuum surface. The digital version of the curvature computation method is shown to obey the scaling laws derived for the continuum version. Several examples, both quantitative and qualitative, are computed of surfaces evolving under curvature differences, and are shown to agree with the known physics of sintering.

163.   Pommersheim, J.; Nguyen, T.; Zhang, Z.; Lin, C.; Hubbard, J.
Mathematical Model of Cathodic Delamination and Blistering Processes in Paint Films on Steel.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1293;   72 p. May 1992.
Available from National Technical Information Services
PB92-217595

paint; mathematical models

Conceptual and mathematical models are developed for processes which describe blistering of defect-containing coating on coated steel containing defects exposed to electrolytic solutions. The assumption is made that cations migrating along the coating/metal interface from an anode at the defect to cathodic sites are responsible for blistering. The cations are driven by both concentration and electrical potential gradients. The mathematical models are solved to predict ion fluxes and concentrations along the interface and within the blister. Solutions of the models are expressed in terms of dimensionless parameters. Model variables include blister size, distance between the blister and defect, ion diffusivity and potential gradients. To substantiate the models, an experiment was designed and conducted to measure the transport of cations along the coating/metal interface from the defect to the blister. Sodium ion concentration-time data within a blister were analyzed to determine model parameters. Under the experimental conditions employed, it was found that the transport of sodium ions is controlled by potential gradients rather than concentration gradients. Model results indicate that large blisters subject to a potential gradient are more likely to grow than small ones because higher concentrations can build up within them. Implications of this conclusion for maintaining the integrity of organic coatings are discussed.

164.   Portier, R. W.; Reneke, P. A.; Jones, W. W.; Peacock, R. D.
User's Guide for CFAST Version 1.6.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4985;   106 p. December 1992.
Available from National Technical Information Services
PB93-140788

compartment fires; fire growth; mathematical models; numerical models; room fires; smoke; toxicity

CFAST is a zone model capable of predicting the environment in a multi-compartment structure subjected to a fire. This guide provides a detailed description of the pre- and post-processing routines used by the model, the data input requirements and the output produced by version 1.6 of the model.

165.   Priestly, N.; Lew, H. S.
U. S. Japan Cooperative Research in Precast Seismic Structural Systems (PRESS) Program: Status Report.
National Institute of Standards and Technology, Gaithersburg, MD

NIST SP 843;   September 1992.
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 24th. May 19-22, 1992, NIST SP 843, Tsukuba, Japan, Raufaste, N. J., Editor, 69-70 pp, 1992.
Available from Government Printing Office
SN003-003-03180-1

> buildings; concretes; earthquakes; precase; seismic; structures

The Precast Seismic Structural Systems (PRESSS) research program was initiated as the fourth topic in the United States-Japan coordinated program on large scale testing for seismic response. The first three topics were reinforced concrete, steel and masonry. The purpose of this coordinated research program is to develop recommendations for the seismic design of buildings constructed of precast concrete systems based on sound analytical and experimental research. This report describes the scope of the joint program and the current projects being carried out by U. S. researchers.

166.   Quintiere, J. G.
Semi-Quantitative Model for the Burning Rate of Solid Materials.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4840;   42 p. June 1992.
Available from National Technical Information Services
PB92-213362

> burning rate; extinction; heat of gasification; fire models

An analytical model was developed to describe the processes involved in the burning and extinction of solid materials. Included are flame heat transfer, charring, transient conduction, and water application. The model qualitatively describes the burning rate of both charring and thermoplastic-like solids. It illustrates how the steady-state heat of gasification can be derived from peak burning rate test data taken as a function of irradiance. Experimental data are shown to support this derivation. The model, in conjunction with a critical flame temperature, is used to describe suppression and extinction by water.

167.   Raufaste, N. J.
Building and Fire Research Project Summaries 1992.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4796;   131 p. March 1992.
Available from National Technical Information Services

> building controls; building research; coatings; combustion; flammability; computer integrated construction; concretes; earthquakes; earthquake engineering; fire research; fire dynamics; fire hazard; combustion physics; fire safety; heat transfer; heat and moisture transfer; large fires; indoor air quality; lighting; quality assurance; refrigeration; smoke dynamics; structural performance; fire suppression; test procedures; toxicity

This report summarizes the Building and Fire Research Laboratory's research for 1992. The report is arranged by its research programs: structural engineering, materials engineering, mechanical and environmental systems, fire science and engineering, and fire measurement and research. Each summary lists the project title, point of contact, sponsor, research and results. BFRL's mission is to increase the usefulness, safety, and economy of constructed facilities, and reduce the human and economic costs of unwanted fires in buildings.

168.   Raufaste, N. J.
Research Lab Plays Role in Reducing Fire Damage.
National Institute of Standards and Technology, Gaithersburg, MD
American Consulting Engineer, Vol. 3, No. 3, 27-28, Summer 1992.

> fire damage; fire research; research facilities

Fires take an enormous toll in the United States. In an average year, losses from fire include: 5,200 fatalities, 29,000 injuries, and a cost to the economy in excess of $120 billion. Research aimed at cutting those costs is being conducted

by the National Institute of Standards and Technology's (NIST) Building and Fire Research Laboratory (BFRL) in Gaithersburg, MD.

169.   Raufaste, N. J., Editor
Wind and Seismic Effects.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 843;   September 1992.
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects.
Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 24th. May 19-22, 1992, NIST SP 843, Tsukuba, Japan, Raufaste, N. J., Editor, 636 pp, 1992.
Available from Government Printing Office
SN003-003-03180-1

> accelerograph; bridges; building technology; concretes; design criteria; disasters; disaster reduction; earthquakes; geotechnical engineering; ground failures; lifelines; liquefaction; masonry; repair and retrofit; risk assessment; seismic; soils; standards; storm surge; structural engineering; tsunamis; wind loads

This publication is the proceedings of the 24th Joint Meeting of the U. S.-Japan Panel on Wind and Seismic Effects. The meeting was held at the National Institute of Standards and Technology, Gaithersburg, Maryland during May 19-22, 1992. The proceedings include the program, list of members, panel resolutions, task committee reports, and 45 technical papers. The papers were presented under five themes: (I) Wind Engineering, (II) Storm Surge and Tsunami, (III) Joint Cooperative Research Program, (IV) Earthquake Engineering, (V) Summaries of Task Committee Workshop Reports (oral presentations only).

170.   Rehm, R. G.; Forney, G. P.
Note on the Pressure Equations Used in Zone Fire Modeling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4906;   34 p. August 1992.
Available from National Technical Information Services

> zone models; equations; fire models; mathematical models; numerical integration; ordinary differential equations; phase plane analysis; singular perturbation analysis

Examples of simple zone fire models are analyzed. These models illustrate the nature of the numerical problems commonly encountered in zone models of enclosure fires. Often these difficulties arise in the solution of the equations for the pressure in connected rooms because the pressure equilibrates much more rapidly than other dynamical variables. Since these models are very simple, analytical techniques can be applied and some insight gained regarding the nature of these problems. The models consist of ordinary differential equations coupled with algebraic equations. Singular perturbation methods and phase plane analyses, together with numerical integration of the appropriately nondimensional-ized equations, are employed to examine the stiff nature of the equations associated with these models. We conclude that many of the difficulties associated with numerical integration of zone fire models in general may be circumvented by appropriate analysis of the zone fire model equations.

171.   Richards, R. F.
Measurements of Moisture Diffusivity for Porous Building Materials.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
Thermal Performance of the Exterior Envelopes of Buildings V. Proceedings of the ASHRAE/DOE/BTECC Conference.   December 7-10, 1992, Clearwater Beach, FL, ASHRAE, Atlanta, GA, 501-516 pp, 1992.

> building materials; porous materials; moisture; diffusivity; moisture content

Moisture diffusivities of several common porous building materials were determined experimentally. Both wood-based and inorganic materials were included in the study. A steady-flux method was used that involved determining the

one-dimensional moisture content profile produced in a sample through which a known constant flux of water is flowing. The transient mass fluxes through samples upon exposure to water, steady-state mass fluxes, one-dimensional moisture content profiles, and capillary pressure curves for low suction pressures, as well as the moisture diffusivities for a range of moisture contents, are presented for each material. Results of the study are compared to previously published measurements for similar materials.

172. Richards, R. F.; Burch, D. M.; Thomas, W. C.
Water Vapor Sorption Measurement of Common Building Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Virginia Polytechnic Inst., Blacksburg
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
Annual Meeting, 1992. Technical and Symposium Papers. ASHRAE Transactions, Volume 98, Part 2, 1992. June 27-July 1, 1992, BA-92-6-1, Baltimore, MD, ASHRAE, Atlanta, GA, 475-485 pp, 1992.

> water vapor; building materials; salt water; moisture content; humidity; sorption measurements

Sorption isotherm measurements were carried out for common building materials. The measurements were made by placing small specimens of the materials in pint-size jars above saturated salt-in-water solutions that gave various ambient relative humidities. The jars were kept at constant temperature until the enclosed specimens reached their steady-state equilibrium moisture content. The equilibrium moisture content plotted versus ambient relative humidity at a given temperature gave the sorption isotherm. Separate sorption isotherms were obtained for specimens initially dry (adsorption isotherm) and for specimens initially saturated (desorption isotherm). The materials included sugar pine, southern pine, exterior-grade plywood, waferboard siding, oriented strand board, particleboard, fiberboard sheathing, sturdy-brace fiberboard, kraft paper, foam-core sheathing, plain gypsum board, and vinyl-covered gypsum board. The sorption measurements were compared to other measurements reported in the literature. Data from the present work were found to lie below many of the previously reported sorption measurements. However, the bias is small, less than 0.05 kg/kg in all cases where equilibrium moisture contents ranged from 0 to 0.30 kg/kg. The use of desiccant drying in this study versus oven drying in previous studies is examined as a possible explanation.

173. Rossiter, W. J., Jr.; Martin, J. W.; Lechner, J. A.; Seiler, J. F., Jr.
Creep-Rupture Resistance of Seam Specimens Sampled From In-Service EPDM Roof Membranes.
National Institute of Standards and Technology, Gaithersburg, MD
International Waterproofing Association. International Conference, 8th. May 1992, Brussels, Belgium, 331-343 pp, 1992.

> roofs; membranes; seams; adhesives; roofing (finishes); creep tests; rubber; sheets

Samples of seams having neoprene-based and butyl-based adhesives were cut from two EPDM roofing systems that were 86 and 39 months old. Creep-rupture tests in a T-peel configuration were conducted on specimens cut from the samples and the results compared with the measured short-term peel strengths of companion specimens. The thickness of the adhesive layer was measured for each specimen. The creep-rupture results were also compared with those from previous studies on laboratory-prepared specimens. The analysis showed that the peel strengths of the seams were typical of non-primed neoprene-based and butyl-based seams sampled from roofs in service. The thicknesses of the adhesive layers were generally greater than those found in specimens previously cut from roofs. In general, the times-to-failure for these field specimens (which had relatively thick adhesive layers) were considerably greater than those found for laboratory specimens prepared using well-cleaned EPDM rubber and thin layers of adhesive.

174. Rossiter, W. J., Jr.; Martin, J. W.; Lechner, J. A.; Seiler, J. E., Jr.
How to Enhance EPDM's Creep-Rupture Resistance.
National Institute of Standards and Technology, Gaithersburg, MD
Professional Roofing, Vol. 22, No. 7, 2-28, July 1992.
Roofing and Waterproofing Congress, 8th International, Madrid, Spaid, 1992.

> membranes; creep tests; rupture; adhesives; roofs; peel strength

Vulcanized ethylene propylene diene terpolymer (EPDM) rubber reportedly comprise about one-third of the low-sloped roofing membranes applied annually in the U.S. To pinpoint factors affecting seam performance in these membranes, the U.S. National Institute of Standards and Technology (NIST) is sampling field installations. These studies have already shown that one of the important factors is the thickness of the adhesive layer in EPDM seams. Results of lab studies, wherein seam specimens were evaluated under creep-rupture conditions in a peel configuration, shown that specimens having thick layers of adhesive are markedly more resistant to delamination than those having relatively thin layers. In contrast, results from previously analyzed field samples show that adhesive layers of field-fabricated seams are relatively thin in relation to the adhesive layers of the more creep-resistant laboratory-prepared specimens.

175.   Rossiter, W. J., Jr.; Nguyen, T.; Byrd, W. E.; Seiler, J. F., Jr.; Lechner, J. A.; Bailey, D. M.
Repairing Aged EPDM: The Cleaner the Sheet, the Stronger the Bond.
National Institute of Standards and Technology, Gaithersburg, MD
Army Construction Engineering Research Lab., Champaign, IL
Professional Roofing, Vol. 22, No. 7, 24-28, July 1992.

        rubber; cleaning; roofing (finishes); membranes

Volcanized EPDM rubber is essentially non-polar and relatively inert, which makes the bonding of sheets to fabricate roof membranes exacting. A factor affecting seam performance that has not been addressed in research studies to date is the condition of the surface of aged EPDM rubber before bonding to it. This factor has importance, because as time passes, patches and splices to EPDM membranes in service may be needed.

176.   Rubin, A. I.
Office Workspace for Tomorrow DOT Workshop (November 13-14, 1991) Contributed Papers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4801;   190 p. March 1992.
Available from National Technical Information Services
PB93-113652

        office buildings; building design; lighting equipment; furniture; architecture; architectural programming; building environment systems; design module; information systems; office-of-the-future; office technologies; telecommunications; workstation design; workstation standards

This report contains a series of papers prepared for the Department of Transportation to assist them in planning a new Headquarters Building. Eighteen experts, representing various disciplines associated with building design and use participated in a workshop, and prepared papers prior to the meeting. The present report contains these papers.
Workshop presentations covered the following topics: workshop design process, programming tradeoffs, workstation standards and criteria, ergonomics, human resource issues, leading edge workstation design, impact of new technologies on office and workstation design, lighting, environmental technologies, information and data systems, building design, facility management, forecasts of the office-of-the-future. These issues were discussed by panel members, and with representatives from the Department of Transportation and other federal agencies. The transcript of the presentations and the discussions that followed will be published in a separate report.

177.   Rubin, A. I.
Office Workspace for Tomorrow DOT Workshop (November 13-14, 1991) Transcript of Proceedings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4802;   221 p. July 1992.
Available from National Technical Information Services

        architectural programming; building design; building environment systems; design module; furniture; information systems; lighting; office-of-the-future; office technologies; telecommunications; workstation design; workstation standards

This report contains the proceedings of a workshop conducted November 13 and 14, 1991 for the Department of Transportation (DOT). The workshop was held to assist the Department in planning a new Headquarters Building. Eighteen experts, representing various disciplines associated with building design and use participated in a workshop, and prepared papers prior to the meeting. The present report consists of the edited transcript of the meeting - presentations and discussion. An earlier report (NISTIR 4801), contains the prepared papers. Workshop presentations covered the following topics: workstation design process, programming tradeoffs, workstation standards and criteria, ergonomics, human resource issues, leading edge workstation design, impact of new technologies on office and workstation design, lighting, environmental technologies, information and data systems, building design, facility management, forecasts of the office-of-the-future. These issues were discussed by panel members, and with representatives from the Department of Transportation and other federal agencies.

178. Saito, K.; Inamura, T.; Ito, A.; Ling, S.; Tagavi, K.; Evans, D. D.
Study of Crude Oil Combustion Supported on Water. Part 1. Study of Boilover in Liquid Pool Fires Supported on Water: Effects of In-Depth Absorption. Part 2. Holographic Interferometry Temperature Measurements in Liquids for Pool Fires. Final Report.
Kentucky Univ., Lexington
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Science and Technology, Vol. 86, 105-119, 1992.

crude oil; combustion; water; pool fires; liquid fires; holographic interferometry; temperature measurements
Part 1. This study is the continuation of previous study (Part 1) on boilover of liquid fuels supported on water. Previously we designed a small scale pool fire apparatus and tested seventeen different (single and multicomponent) liquid fuels on water. Based on those established data, in this paper we have described a one-dimensional model to predict the time required for the water sublayer to start to boil (TWSB). The model includes unsteady term of thermal energy equation, conduction and in-depth radiation absorption. To fully implement the model, radiation absorption was measured for toluene and Alberta Sweet crude oil as a function of fuel layer thickness. The model calculation predicts formation of the inverse temperature profiles in the liquid due to the effect of in-depth absorption. Occurrence of the predicted Rayleigh convection in fuel layer is confirmed using a holographic interferometry technique, and it's effect on TWSB is estimated by comparing the model calculations to the experimental results. It is found that significant amount of heat is transferred from the fuel open surface to fuel-water interface by Rayleigh convection, while the heat loss to the wall is found to be at moderate levels. Part 2. This study provides detailed temperature and physical structure measurements within both the n-decane fuel layer and the supporting water sublayer at the onset of the boiling of water sublayer WSB). Understanding the mechanisms of WSB is important to predict the so-called "boilover phenomenon" which is associated with an intense spattering of water and fuel droplets. The in-depth physical structure and temperature profiles were obtained using a holographic interferometry technique with Pyrex rectangular containers with large aspect ratios to provide two-dimensional conditions. The experiments demonstrated that: (1) Maximum temperature was achieved 0.1-0.15 cm below the fuel surface possibly due to in-depth radiation absorption which caused Rayleigh convection in the fuel layer near the surface, and (2) The fuel surface remained at a saturation temperature approximately 20K below the boiling point, while the water at the fuel-water interface was superheated. The superheated water layer is dynamically unstable, so that sporadic spatterings of water and fuel droplets (boilover) were observed. To check the applicability of these results to a larger pool fire system a Pyrex pan of 6 cm diameter was used; and occurrence of Rayleigh convection was confirmed using a streak shadow graph technique.

179. Shenton, H. W., III
Design Criteria for Base Isolation of Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 843;   September 1992.
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 24th. May 19-22, 1992, NIST SP 843, Tsukuba, Japan, Raufaste, N. J., Editor, 165-171 pp, 1992.
Available from Government Printing Office
SN003-003-03180-1

building codes; design applications; base-isolation; dynamic response; relative performance; steel frame; structures; steels

Presented are the results an investigation in which the performance of "code-designed" fixed-base and base-isolated structures were compared. Two frames, a steel concentrically braced frame and a steel special moment resisting frame were designed as both fixed-base and base-isolated in accordance with the 1991 Uniform Building Code. To establish comparable performance, the base-isolated frames were designed to varying fractions of the code recommended base shear: 100%, 50% and 25%. Non-linear time history analyses were conducted, for three ensembles of earthquakes, to assess the effect of design force level and base-fixity on response and damage level. In general, the base-isolated frames designed to 100% of the code recommended base shear out-performed the fixed-base frames. Based on average values of a number of response quantities, comparable performance could be achieved at design forces lower than currently specified by code for the base-isolated frames.

180.   Shenton, H. W., III; Anderson, E. D.; Gross, J. L.; Marshall, R. D.
NIST Impact Test Facility.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4896;   26 p. January 1992.
Available from National Technical Information Services
PB92-226315

impact testing; test facilities; building technology; drop tower; dynamic response; impact; impulsive load

The National Institute of Standards and Technology has recently constructed an Impact Test Facility (ITF), which is to be used in the investigation of the behavior of structural elements and systems subject to loads of short duration and high intensity. The ITF consists of a 21.9 m vertical drop tower and free-fall impactor. A peak impact velocity of 17 m/s can be attained in the ITF with a full-height drop, delivering 8,500 N-m of kinetic energy to a specimen using a 59 kg impact sled. The components of the system include the vertical drop tower, impact sled, sled hoist assembly, sled fall arresting system, specimen support frame, instrumentation and data acquisition system. The system has been designed to be versatile and can be adapted to meet a wide variety of test requirements.

181.   Simiu, E., Editor
Reliability of Offshore Operations: Proceedings of an International Workshop. March 20-22, 1991, Gaithersburg, MD 237 pp, 1992.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 833;   April 1992.
Available from Government Printing Office
SN003-003-03148-8
Available from National Technical Information Services
PB92-183748

offshore platforms; codes; drilling; petroleum products; regulations; reliability; risk analysis; standards; gas production; marine engineering; ocean engineering; oil production; shipping

The proceedings of an International Workshop held at the National Institute of Standards and Technology on March 20, 21 and 22, 1991 are presented. The purpose of the Workshop was to examine new developments in the application of risk analysis in offshore oil and gas operations. The proceedings include: an executive summary, invited papers on current practice in the United States, Canada, the united Kingdom, and Norway, and summary reports and recommendations of six Working Groups: (1) Experience Data Bases and Case Study Analyses; (2) Risk Management Practices; (3) Structures: Risk and Reliability Issues; (4) Production Facilities; (5) Pipelines and Subsea Systems; and (6) Drilling Operations. Also included are Working Group theme papers.

182.   Simiu, E.; Cook, G. R.
Empirical Fluid-Elastic Models and Chaotic Galloping: A Case Study.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Sound and Vibration, Vol. 154, No. 1, 45-66, 1992.

fluid-elastic models; chaotic galloping; experiments; case histories; bluff body; equations; oscillator; motion; numerical analysis

To describe the behavior of bluff body fluid-elastic motions, analysts must in practice resort to empirical models based on a limited number of measured fluid-elastic behavior characteristics. To our knowledge the question of whether such models can predict reliably the actual occurrence of chaos has not yet been addressed. With a view to answering this question in a specific case, we present an exploratory experimental and numerical study of two paradigmatic fluid-elastic systems: (1) a single galloping square prism; and (2) a pair of elastically coupled galloping prisms which can exhibit apparently chaotic behavior of interest from a structural engineering viewpoint. We review various conventional empirical models and their capabilities, and develop a model that incorporates information on the dependence on angle of attack of the vortex-induced lift coefficient and the Strouhal number for the stationary prism. For appropriate values of the adjustable parameters and initial conditions, this model appears to be able to describe observed behavior at least qualitatively. However, the predictive capabilities of the model are poor, especially for apparently chaotic behavior. A possible approach to improving the reliability of the numerical detection of such behavior is suggested.

183.   Simiu, E.; Frey, M.
Noise Modeling and Reliability of Behavior Prediction for Multi-Stable Hydroelastic Systems.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers (ASME). Offshore Mechanics and Arctic Engineering, 11th International Conference. Book No. H00753. Am. Soc. of Mechanical Engineers, New York, NY, Soares, C. G.; Murotsu, Y.; Pittaluga, A.; Spencer, J. S., Editors, 39-44 pp, 1992.
        noise (sound); experiments; equations
This paper reviews results of experiments conducted on a simple multi-stable hydroelastic (galloping) oscillator. These results show that noise may cause a multi-stable hydroelastic system to exhibit chaotic behavior, and that in some instances such behavior cannot be predicted reliably unless noise effects are carefully accounted for. We then present results of a theoretical investigation of a simple, paradigmatic multi-stable system, the Duffing-Holmes oscillator. The results of this investigation show that for the system being considered noise promotes the occurrence of chaotic behavior associated with Smale horseshoes. This theoretical investigation is the first phase of an effort to develop analytical tools for predicting reliably the potential for chaotic behavior of actual hydroelastic systems such as deep-water compliant platforms.

184.   Simiu, E.; Frey, M.; Grigoriu, M.
Necessary Condition for Homoclinic Chaos Induced by Additive Noise.
National Institute of Standards and Technology, Gaithersburg, MD
Cornell Univ., Ithaca, New York
Computational Stochastic Mechanics, Elsevier Applied Science, New York, Spanos, P. D.; Brebbia, C. A., Editors, 889-896 pp, 1992.
        noise (sound); homoclinic orbit
The effect of noise on the possible occurrence of chaos in systems with a homoclinic orbit was recently investigated in the literature on the basis of a redefinition of the Melnikov function. The purpose of this note is to show that, even in the case of deterministic equations, this redefinition is not consistent with the geometry of the perturbed orbits and would therefore lead to incorrect solutions. The possibility is then explored of developing a necessary condition for the occurrence of homoclinic chaos in forced systems perturbed additively by a commonly used approximate representation of white noise.

185.   Sjolin, V.; Evans, D. D.; Jason, N. H., Editors
First International Conference on Fire Suppression Research.
BRANDFORSK, Stockholm, Sweden
National Institute of Standards and Technology, Gaithersburg, MD
Swedish Fire Research Board and National Institute of Standards and Technology. Fire Suppression Research Conference, 1st International. May 5-8, 1992, Stockholm, Sweden, 427 pp. 1992.
        fire suppression; fire research; fire extinguishment; fire extinguishing agents; halons; fire departments; water sprays; water droplets; fire models; dry powders; sprinklers

This report contains the Research Priorities, Recommendations and technical papers presented at the Stockholm conference. The conference was organized to bring together a cross-section of the researchers, users, and sponsors of fire suppression research worldwide. BRANDFORSK (Swedish Fire Research Board) and NIST (National Institute of Standards and Technology) jointly organized the conference that was held in Stockholm.

186. Sjolin, V.; Evans, D. D.; Jason, N. H., Editors
First International Conference on Fire Suppression Research: Summary.
BRANDFORSK, Stockholm, Sweden
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4946;   47 p. October 1992.
Available from National Technical Information Services
PB93-124964

> fire suppression; fire research; fire extinguishment; fire extinguishing agents; halons; fire departments; water sprays; water droplets; fire models; dry powders; sprinklers

This report contains the Research Priorities, Recommendations and Summaries of papers presented at the Stockholm conference. The conference was organized to bring together a cross-section of the researchers, users, and sponsors of fire suppression research worldwide. BRANDFORSK (Swedish Fire Research Board) and NIST (National Institute of Standards and Technology) jointly organized the conference that was held in Stockholm. The complete proceedings are available from NIST and BRANDFORSK.

187. Smith, R. L.
New Heater and Flux Gauge for the NBS Smoke Box.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4917;   30 p. September 1992.
Available from National Technical Information Services
PB93-11367

> smoke chamber test; smoke measurement

Improvements of the heater and the heat flux detector used in the FAA's (Federal Aviation Administration) Smoke Chamber test protocol are described. Heater designs were evaluated and two heaters were obtained and evaluated. This report covers various aspects of analysis and gives details on the heater that may provide a more uniform radiation field on the target specimen. The use of a smaller gauge, similar to the one used in the OSU calorimeter, in the smoke box for measuring the heat flux is discussed. Finally, a method that allows one to use the measurement of the radiation field at the center of the target specimen to infer the average radiation field over the specimen is presented.

188. Smith, S. B., Editor
Annual Conference on Fire Research. Abstracts.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4924;   September 1992.
Available from National Technical Information Services

> fire research; fire plumes; flame spread; fire suppression; mathematical models; halons; microgravity; fire detection; polymers; vents; sprinklers; pool fires; soot; toxic gases

The NIST Annual Conference on Fire Research has long been the prime forum for the presentation and discussion of the latest advances in the science of fire and the engineering of fire safety. This year's conference has been expanded to include all fire research performed within Federal laboratories or sponsored by Federal agencies, as well as by laboratories around the world.

189. Snell, J. E.
Internationalization of Fire Safety Engineering Research and Strategy. Session 1: Opening and Keynote Address.
National Institute of Standards and Technology, Gaithersburg, MD
CSIRO. International Fire Safety Engineering Conference. Concept and the Tools.

Presented for FORUM for International Cooperation on Fire Research. Supported by SFPE, NFPA, AFPA, AAFA. October 18-20, 1992, Sydney, Australia, 1-13 pp, 1992.

fire safety; safety engineering; economic factors; technology transfer; fire science; fire research

Fire is still a significant problem of loss and/or cost to most nations of the world. Advances in science, engineering and technology are leading to the emergence of fire safety engineering as a discipline. This paper addresses this new era of fire safety engineering, the trends and other factors driving it, what it means to how we provide fire safety in our societies, and why an international strategy for its further development is in our mutual interest. The role of the Forum for International Cooperation on Fire Research is discussed and actions are suggested.

190.   Snell, J. E.
Fire Safety Engineering Research in the USA. Session 3: Fire Safety Engineering Research.
National Institute of Standards and Technology, Gaithersburg, MD
CSIRO. International Fire Safety Engineering Conference. Concept and the Tools.
Presented for FORUM for International Cooperation on Fire Research. Supported by SFPE, NFPA, AFPA, AAFA. October 18-20, 1992, Sydney, Australia, 1-11 pp, 1992.

fire safety; safety engineering; fire research; building design; fire risk; hazard assessment

This paper describes fire research in the United States and particularly the fire research program at the National Institute of Standards and Technology. The United States has one of the highest fire death rates of the nations of the world and the total cost of fire safety to the nation is $128 billion per year. First, it comments on the background to this program, and then describes the context in which it functions, i.e., the building regulatory and product approval systems and other fire research activities in the USA. Next, it outlines the rationale for NIST fire research and notes some of the research products and their impacts. The fire research program of the Building and Fire Research Laboratory of the National Institute of Standards and Technology is aimed at reducing the heavy burden of these losses through developing the technical basis for fire safety engineering and helping to get these new tools used. This program focuses on three areas: scientifically-based tools for fire risk and hazard prediction; fire safe products and materials; and advanced sensing and suppression technologies. This is roughly an $8 million program involving the efforts of approximately 80 staff.

191.   Snyder, K. A.; Clifton, J. R.; Carino, N. J.
Nondestructive Evaluation of the In-Place Compressive Strength of Concrete Based Upon Limited Destructive Testing.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4874;   68 p. July 1992.
Available from National Technical Information Services

concretes; break-off; nondestructive testing; probe penetration; pull-out; pulse velocity; rebound hammer; regression analysis; strength estimation

Regression analysis was performed on published data from nondestructive and cylinder compressive strength testing of concrete. The nondestructive tests investigated were: rebound hammer, probe penetration, pulse velocity, pullout, and break-off. Regression analysis accounted for the error in both the nondestructive and the compressive strength data and their constant coefficient of variation. Data for each nondestructive test were grouped by coarse aggregate type and aggregate mass fraction. The results of the regression analysis are given, along with the parameters required to estimate compressive strength from subsequent nondestructive tests. A common format for the analysis and reporting of nondestructive-destructive regression experiments is suggested.

192.   Snyder, K. A.; Garboczi, E. J.; Day, A. R.
Elastic Moduli of Simple Two-Dimensional Isotropic Composites: Computer Simulation and Effective Medium Theory.
National Institute of Standards and Technology, Gaithersburg, MD
Marquette Univ., Milwaukee, WI
Journal of Applied Physics, Vol. 72, No. 12, 5948-5955, December 15, 1992.

elastic moduli; composite materials; simulation; algorithms

An algorithm, combining digital-image with spring network techniques, has been developed that enables computation of the elastic moduli of random two-dimensional multiphase composites. This algorithm is used to study the case of isotropic, randomly centered, overlapping circular inclusions in an isotropic elastic matrix. The results of the algorithm for the few-inclusion limit, as well as the case where both phases have the same shear moduli, agree well with the results for these two problems. The case where the two phases have the same Poisson's ratio, but different Young's moduli, is also studied, and it is shown that the effective medium theory developed by Thorpe and Sen agrees well with the numerical results. A surprising result is that the effective moduli of systems with nonoverlapping circular inclusions are almost identical with the overlapping inclusion case, up to an inclusion area fraction of 50%.

193. Snyder, K. A.; Winslow, D. N.; Bentz, D. P.; Garboczi, E. J.
Interfacial Zone Percolation in Cement-Aggregate Composites.
National Institute of Standards and Technology, Gaithersburg, MD
Purdue Univ., West Lafayette, IN
RILEM. Interfaces in Cementitious Composites. International Conference. Proceedings 18. October 21-23, 1992, Toulouse, France, E & FN Spon, New York, Maso, J. C., Editor, 259-268 pp, 1992.

      composite materials; percolation; hard core-soft shell; microstructure; computer models; interfacial zone; mercury intrusion

Interfacial zones exist between the aggregates and paste in portland cement mortars and concretes. The microstructure of these interfacial zones consists of both larger pore diameters and higher porosity than the microstructure of the bulk paste. If a sufficient number of the aggregate particles are present, the interfacial zones may overlap and link together, percolating the system. Mercury intrusion experiments performed on mortars indicate that the intrusion characteristics change dramatically at a critical sand content. A computer simulation model has been developed that can predict the volume of sand required for the percolation of the interfacial zone phase given an interfacial zone thickness and an aggregate size distribution. The model was used to simulate 1 cm3 of mortar, consisting of approximately 10000 aggregate particles. A comparison of the results of the computer simulation model with the results of the mercury intrusion experiment yields an estimate of the interfacial zone thickness which is in agreement with published values. The model is also applied to 27 cm3 systems of concrete in order to predict the critical aggregate content required for percolation.

194. Stone, W. C.; Taylor, A. W.
Predictive Model for Hysteretic Failure Parameters.
National Institute of Standards and Technology, Gaithersburg, MD
World Conference on Earthquake Engineering, 10th. July 19-24, 1992, Madrid, Spain, A. A. Balkema/Rotterdam/Brookfield, 2575-2580 pp, 1992.

      reinforced concretes; bridges (structures); earthquakes; parameters; failure; failure models; digital test records; system identification; regression analysis

The ability to analytically predict the inelastic dynamic behavior of reinforced concrete bridge structures during earthquakes is predicated on the availability of an appropriate hysteretic failure model. To date, several such models have been implemented in research computer codes with little or no information available concerning the selection of appropriate coefficients and parameters for the solution of a specific type of reinforced concrete structure. A digital database of load-displacement histories was established for circular, spirally reinforced bridge column tests. A system identification analysis was performed on each specimen in which the error in cyclic absorbed energy was minimized by optimal selection of parameters in a tri-linear hysteretic failure model. Three parameters, comprising a stiffness degrading coefficient, a strength degrading coefficient, and a pinching coefficient, were employed in this study. Subsequent multivariable least squares regression analyses were conducted to correlate the variation of the model parameters with the specimens' physical properties. Regression equations were developed for the parameters alpha, betta, and gamma and explanations are offered as to the correlation of the parameters to material and geometric properties of the columns.

195. Struble, L.; Garboczi, E.; Clifton, J.
Durability of High-Performance Cement-Based Materials.
Illinois Univ., Urbana
National Institute of Standards and Technology, Gaithersburg, MD
Materials Research Society. Materials Research Society Symposium Proceeding. Volume 245.

1992, 329-340 pp, 1992.

cements; durability; reinforced concretes; service performance; concretes

There is considerable research now underway on high-performance cement-based materials, in particular on issues of processing, microstructure, strength, and related properties. However, very little research has been undertaken regarding the durability, or service performance, of these materials. Therefore the durability of high-performance cement-based materials can only be inferred from the service performance of ordinary materials or from a basic understanding of the factors affecting service performance. In this paper we review what is known about the durability of fiber reinforced concrete, high performance concrete, DSP and MDF. Durability is discussed from the standpoint of general issues -- fluid permeability, ionic diffusivity, and pore fluid composition. Much research is needed in order to predict or improve the durability of high performance cement-based materials.

196.   Stutzman, P. E.
X-Ray Powder Diffraction Analysis of Three Portland Cement Reference Material Clinkers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4785;   25 p. April 1992.
Available from National Technical Information Services
PB92-183664

cements; x-ray diffraction; microscopy; quantitative analysis; cement clinker; reference
materials

Three portland cement clinker Reference Materials (RMs) are now available from the National Institute of Standards and Technology (NIST). They are intended for use in testing and developing methods for quantitative phase abundance analysis and have been selected as representative of the range of compositions and textures of North American clinkers. Quantitative X-ray powder diffraction analysis was used to determine the phase abundance composition and compositional variability of eight randomly selected samples from each RM. In addition, each sample was split for duplicate analyses for evaluation of intra-sample phase abundance variability. The Reference Intensity Ratio method was used for powder diffraction calibrations and quantitative analysis. Both pure-phase standards and subsamples of the RM clinkers, which were point counted using the scanning electron microscope, were used for calibrations. Phase abundance values generally agree with those reported in earlier studies and the inter-sample standard deviation values were generally less than or equal to the intra-sample standard deviation values.

197.   Stutzman, P. E.; Clifton, J. R.
Microstructural Features of Some Low Water/Solids, Silica Fume Mortars Cured at Different Temperatures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4790;   17 p. April 1992.
Available from National Technical Information Services

cements; silica; hydration; microscopy; x-ray diffraction; curing temperature; microstructure; mortar; silica fume

The microstructure of mortars with water/solids ratios (w/s) of 0.36 and 0.29, cured under water at 7, 23, and 4 deg C, were studied by scanning electron microscopy and x-ray powder diffractometry. The mortars contained silica fume and a superplasticizer. The degree of hydration and extent of pozzolanic reaction was estimated after quantifying the residual unhydrated cement by image analysis and the mass percent calcium hydroxide by x-ray powder diffraction. Their microstructures were fairly homogeneous in both the bulk paste and at the paste-aggregate transition zone. In all mortars, the outer 250 mum was hydrated to about 85 percent and highly microcracked. The degree of hydration decreased rapidly beyond the outer zone to about 69 percent and less microcracking was observed. A temperature effect on the reactivity of silica fume was found.

198.   Subramaniasiva, H.
Soot Formation in the Buoyancy-Dominated Ethane Diffusion Flame.
Brown Univ., Providence, RI
NIST-GCR-92-609;   46 p. July 1992.

soot; soot formation; diffusion flames; fuel flow rate; air flow; sampling; ethylene; laminar flames; lasers; particle size

A sampling technique, based on the phenomenon of thermophoresis is used here, in order to study the soot morphology within a buoyancy-dominated ethene diffusion flame. The buoyancy-dominated flame has a fuel flow rate of 50 cc/s and a co-annular air flow of 107 cc/s. Soot morphologies at each sampling location are obtained on carbon-coated grids through a fast probe drive mechanism, and they are analyzed under a transmission electron microscope. These observations, coupled with temperature measurements at various heights of the buoyancy-dominated flame, leads to a basic understanding of particle inception region, surface growth, aggregate formation, oxidation process, aggregate size and primary particle size within this flame. Change in soot morphology is studied both in the vertical and radial axes of this flame. The intense particle inception region, characterized by a large concentration of liquid-like microdroplets, is contained within the low part of the flame. These microdroplets form on the fuel side of the flame front where the temperature is the highest. Above the inception region aggregates of increasing size are observed, i.e., increasing number of primary particles, while the primary particles themselves undergo surface growth. Surface growth in primary particles ceases to exist above the vortex region of the flame, i.e., above $Z=15$ cm. Since there is very little evidence of oxidation taking place within this buoyancy-dominated flame, it is concluded that most of the soot formed in this flame is released into the surroundings. Observations being made here have been compared to similar soot morphology studies previously made on laminar ethene diffusion flames, both non-sooting and sooting, and laser diagnostic tests.

199. Tan, Q.; Jaluria, Y.
Flow Through a Horizontal Vent in an Enclosure Fire.
Rutgers, State University of New Jersey, New Brunswick
American Society of Mechanical Engineers (ASME). Heat Transfer in Fire and Combustion Systems. HTD-Vol. 199. 1992, Am. Soc. of Mechanical Engineers, New York, NY, 115-122 pp, 1992.

enclosures; vents; air flow; combustion products; compartments; flow rate

The flow of air and combustion products across vents governs the growth and spread of fires in compartments and buildings. The rate of inflow of oxygen from the ambient determines the combustion process and the energy release rate in fires for many practical circumstances. Similarly, the spread of the fire to adjoining areas is strongly dependent on the resulting flow through vents. Horizontal vents are important in many situations, particularly in multi-room compartments, ships and containment buildings. This paper considers the flow through such vents for non-zero pressure and density differences that usually arise across the vent in typical fires. A detailed experimental study is undertaken to understand the basic nature of the flow through a horizontal vent, using fresh and saline water to simulate the density differences that arise in fires due to temperature rise in the enclosure. An externally imposed pressure difference is exerted and the resulting flow rates are measured for a wide range of vent dimensions. In the absence of a pressure difference, a bi-directional flow arises due to buoyancy effects. As the pressure increases, the flow gradually shifts to a un-directional flow. The flow rate at relatively large pressure differences can be obtained from existing vent flow models that are based on Bernoulli's equation. However, typical fire conditions lie in the region where both buoyancy and pressure effects are important. There is very little information available in the literature on this flow regime. The paper presents results on the measured flow rates and also some correlations that consolidate the observed trends. Finally, typical fires in rooms with horizontal vents are examined. The results obtained are considered with respect to the growth and development of fires in vented enclosures, different regimes that may arise and possible periodic variations that have been observed in room fires for certain circumstances.

200. Tan, Q.; Jaluria, Y.
Flow Through Horizontal Vents as Related to Compartment Fire Environments. September 29, 1990-September 30, 1991.
Rutgers Univ., New Brunswick, NJ
NIST-GCR-92-607;   105 p. June 1992.
Available from National Technical Information Services
PB92-213388

vents; compartment fires; convective flow; fire growth; flow rate; room fires

A detailed investigation has been carried out on the flow exchange through a horizontal vent in a compartment containing a fire. A plexiglass tank with a vented horizontal partition in the middle was constructed to simulate the warmer interior environment due to a fire and the cooler ambient environment by filling the upper and lower compartment with brine and pure water, respectively. Experiments have been carried out on the combined natural and forced convection flow by imposing a pressure difference across the vent. The flow rates through the vent were determined over wide ranges of the governing variables, such as the pressure difference delta P across the opening, density difference delta rho across the opening and the opening length to diameter ratio L/D. The basic characteristics of the flow, particularly whether it is unidirectional or bidirectional, was also studied. Volume flow rates were obtained as functions of the governing parameters in terms of correlating equations, from which quantitative information of the effect of delta P, delta rho and L/D on the flow exchange through the vent can be determined. These results can thus be applied to the modeling of fire growth in vented rooms.

201. Tartarini, P.; diMarzo, M.
Solid-Liquid Interfacial Conditions for Dropwise Evaporative Cooling.
Maryland Univ., College Park
ATTI. National Congress on Heat Transfer, 9th. Universita degli Studi di Pisa, Genova, Italy. March 13-14, 1991, Genova, Italy, 61-75 pp, 1992.

> droplets; evaporation cooling; solid surfaces; sprays; hot surfaces; algorithms; equations; formulations

Theoretical research is carried out to describe the thermal behavior of a solid surface subjected to droplet evaporative cooling. The objective of this study is the analysis of various simplified boundary conditions which can be used to generate predictions of the thermal behavior of the solid surface. This study is part of a more general research conducted in order to individuate the global cooling effect of a spray impinging a hot solid surface. A number of numerical algorithms are used to obtain solutions of the governing equations for the various cases examined. Results are presented for the different boundary conditions.

202. Tartarini, P.; Liao, Y.; diMarzo, M.
Numerical Simulation of Multi-Droplet Evaporative Cooling.
Universita di Bologna, Italy
Maryland Univ., College Park
ATTI. National Congress on Heat Transfer, 10th. Universita degli Studi di Genova, Italy. March 25-27, 1992, Genova, Italy, 123-132 pp, 1992.

> droplets; evaporation cooling; numerical analysis; formulations; thermal conductivity; solid surfaces

A theoretical study is carried out to predict the thermal behavior of a solid surface subjected to multi-droplet evaporative cooling. A single-droplet numerical code, which has been previously presented and validated, is used here to gain insight into the behavior of a surface subjected to dropwise evaporative cooling. On the basis of the single-droplet results, a generalized model is presented and a novel numerical code is formulated, which analyzes the effects of a multi-droplet evaporative transient on a low thermal conductivity solid surface. The main parameters that characterize the evaporative transient behavior are identified. Some numerical results obtained with this new model are presented and discussed.

203. Taylor, A. W.; Lin, A. N.; Martin, J. W.
Performance of Elastomers in Isolation Bearings: A Literature Review.
National Institute of Standards and Technology, Gaithersburg, MD
Earthquake Spectra, Vol. 8, No. 2, 279-303, May 1992.

> elastomers; literature reviews; isolation bearings; earthquakes; bridges (structures); ozone; corrosion; temperature effects; high energy radiation

Laminated elastomeric bearings have been used for about 30 years in the United States to isolate bridge substructures from the lateral forces induced by shrinkage and creep of their superstructures. More recently, elastomeric bearings have been increasingly employed in buildings and bridges as a means of decoupling the structure from seismic ground motions. Since most buildings and bridges have service lives of at least 30 to 60 years, questions about the long-term behavior of base-isolation bearings arise. This paper presents a review of literature relating to the long term performance of the elastomers used in seismic isolation bearings. Bearing performance requirements are discussed and material characteristics and fabrication procedures are outlined. Field experience and laboratory findings are reviewed. Finally, long-term

environmental effects are discussed, including ozone degradation, corrosion, temperature effects, and the influence of bombardment of elastomers by high energy radiation.

204.   Todd, D.
World of Building Codes.
National Institute of Standards and Technology, Gaithersburg, MD
Phenomenal News, Vol. 3, No. 3, 1-3, April 1992.
building codes; disasters; seismographs; building construction; standards
Executive Order 12699 requires that federal agencies use appropriate seismic design and construction standards for the construction of all new buildings that are owned, leased, assisted, or regulated by the federal government. The order requires that "nationally recognized private-sector standards and practices" be used, unless such standards are found to be inadequate for agency use. Local building codes may be used if they are found to be adequate. The Interagency Committee on Seismic Safety in Construction (ICSSC), in its Recommended Practice 2.1, "Guidelines and Procedures for Implementation of the Executive Order on Seismic Safety of New Construction," recommends the use of building codes that are substantially equivalent to the "National Earthquake Hazard Reduction Program (NEHRP) Recommended Provisions for the Development of Seismic Regulations for New Buildings." The NEHRP Recommended Provisions themselves are not a building code, but rather a resource document. This article describes how local codes, model codes, national standards, and seismic-design resource documents are related. Figure 1 shows the flow of information among researchers and investigators, resource documents, national standards, and model and local codes.

205.   Todd, D. R.; Bieniaswki, A., Editors
Guidelines and Procedures for Implementation of the Executive Order on Seismic Safety of New Construction.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4852; 26 p. June 1992.
Available from National Technical Information Services
PB92-205343
building construction; earthquakes; safety; agency seismic safety coordinator; earthquake hazard; Executive Order on Seismic Safety; Federal agencies; guidelines; new construction; seismic safety
Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction", was signed by the President to further the goals of Public Law 95-124, the "Earthquake Hazards Reduction Act of 1977", as amended. These guidelines and procedures for implementing the Order have been prepared and endorsed by consensus of the Interagency Committee on Seismic Safety in Construction. The Executive Order applies only to new construction. All buildings owned, leased constructed, assisted (through such methods as loans, grants, or guarantees of loans), or regulated by the Federal government must conform to the requirements of the Order. Each Federal agency is independently responsible for ensuring appropriate seismic design and construction standards are applied to new construction under its purview. These guidelines recommend that each agency name an agency seismic safety coordinator to serve as a focal point for the agency's seismic safety program. Guidelines for determining the adequacy of local building codes are provided. Recommended implementation procedures include requiring written acknowledgement of agency seismic design and construction requirements from the building architect, engineer, contractor, and/or owner.

206.   Tokida, K.; Raufaste, N. J., Editors
List of Publications 1969-1991, Panel on Wind and Seismic Effects of U.S.-Japan Cooperative Program in Natural Resources.
National Institute of Standards and Technology, Gaithersburg, MD
Japan Ministry of Construction, Tsukuba, Japan
NIST SP 835; 97 p. April 1992.
Available from Government Printing Office
SN003-003-03159-3

Available from National Technical Information Service
PB92-201102

> wind effects; seismographs; earthquakes; large-scale testing; lifeline; repair and retrofit; seismic control systems; seismic design; soil behavior; storm surge; structural performance; tsunamis

This publication communicates the results of the work of the Panel on Wind and Seismic Effects during the period 1969 through 1991. The Panel is one of 16 Panels comprising the U.S.-Japan Cooperative Program in Natural Resources. Publications constitute a major end product of the Panel's efforts. This publication is divided into five chapters: 1) Panel background and activities; 2) information about using this publication; 3) title index of Panel publications from 1969 through 1991; 4) title index of Task Committee publications from 1969 through 1991; and 5) author listing.

207. Treado, S. J.; Bean, J. W.
Interaction of Lighting, Heating and Cooling Systems in Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4701;   115 p. March 1992.
Available from National Technical Information Services
PB92-187079

> lighting equipment; heating; cooling; air flow; ventilation; energy; load calculation

The interaction of building lighting and HVAC systems, and the effects on cooling load and lighting system performance, are being evaluated using a full-scale test facility at the National Institute of Standards and Technology. The results from a number of test configurations are described, including lighting system efficiency and cooling load due to lighting. The effect of lighting and HVAC system design and operation on performance is evaluated. Design considerations are discussed.

208. Treado, S. J.; Bean, J. W.
Optical Performance of Commercial Windows.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4711;   178 p. January 1991.
Available from National Technical Information Services

> windows; absorptance; contrast; glazing; privacy; visibility

The role of window system characteristics on privacy-related issues was examined. The optical characteristics of various window materials were measured and compared to determine the best candidates for enhancing building occupant privacy. Strategies for inducing privacy are discussed, along with related performance characteristics of window systems.

209. Treado, S. J.; Goodin, P. J.
Prototype Simplified Daylighting Design Tool.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4842;   22 p. July 1992.
Available from National Technical Information Services
PB92-213321

> prototypes; building design; clerestories; fenestration; lighting; skylights; windows

This report describes a prototype simplified design tool which has been developed to provide information for developing effective building fenestration systems. A computer software system was developed to search through and select the best available fenestration designs from a large database of previously simulated cost or peak loads. The determination of fenestration energy costs is discussed. The design tool is primarily intended for commercial, industrial or institutional buildings of any type.

210. Walton, W. D.
Introduction to Mathematical Fire Modeling. [Book/Software Review of *An Introduction to Mathematical Fire Modeling* by David M. Birk.]

National Institute of Standards and Technology, Gaithersburg, MD
Fire Technology, Vol. 28, No. 1, 87-91, February 1992.

mathematical models; fire models

An Introduction to Mathematical Fire Modeling by David M. Birk is based on the author's master's thesis. The strength of the book is that it provides a substantial level of background material, detailed documentation, validation information and example applications for the author's two-zone mathematical fire model FIRM. FIRM is a single-compartment model which expands on the capabilities of the well known ASET-B computer fire model. The weakness of the book is that the author provides neither a comprehensive review of the overall subject of mathematical fire modeling nor covers the most recent work in the field. The FIRM program, which is included on a floppy disk with the book, is written for interpreted BASIC in a format which is not compatible with the QBASIC provided with DOS 5.0.

211.   Wright, R. N.
Implementation of Executive Order 12699: Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction.
National Institute of Standards and Technology, Gaithersburg, MD
Phenomenal News, Vol. 3, No. 2, 12-14, January 1992.
Fault Line: Official Newsletter of the Central U. S. Earthquake Consortium, Vol. 4, No. 1, 1,3 pp, June 1992.

building construction; safety; earthquakes; seismographs

Losses of property approaching $10 billion, losses of 62 lives, and severe disruption of human activities from the October 17, 1989, Loma Prieta, California, earthquake reminded the United States of the severe threats posed by great earthquakes. In perspective, losses were modest because the earthquake was a distance from the San Francisco Bay area, where the major damages occurred. Unless enhanced efforts are made to reduce earthquake hazards, a large earthquake close to a major metropolitan area can kill tens of thousands of people, cause tens of billions of dollars of direct property losses, and, through consequent losses, severely disrupt economic activity for the whole nation.

212.   Wright, R. N.
Implementation of Executive Order 12699: "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction".
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 843;   September 1992.
U. S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U. S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 24th. May 19-22, 1992, NIST SP 843, Tsukuba, Japan, Raufaste, N. J., Editor, 311-315 pp, 1992.
Available from Government Printing Office
SN003-003-03180-1

building codes; standards; earthquakes; hazard reduction; existing buildings; retrofitting buildings; seismic safety

The Interagency Committee on Seismic Safety in Construction (ICSSC) assists federal agencies involved in construction to develop and incorporate earthquake hazards reduction measures in their ongoing programs. ICSSC proposed an executive order for seismic safety in construction that became the basis for Executive Order 12699, "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction," dated January 5, 1990. ICSSC is working with federal agencies, state and local governments and private sector organizations to implement the Executive Order.

213.   Wright, R. N.
Think Metric.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Structural Engineering, Vol. 118, No. 12, 3253-3254, December 1992.

structural engineering

The modern metric system of measurement, Le Systeme International d'Unites (SI), is coming to structural engineering practice. Federal agencies are required by law to have implemented SI procurements, specifications, grants, etc. by September 30, 1992. Perhaps the most important challenge this brings to structural engineers is having to learn to think quantitatively and exert good engineering judgment in metric units. When we consider computer output or review plans, we must be independently critical of the reasonableness of the results, and not allow our own or others' blunders to pass unquestioned because of unfamiliarity with units.

214.   Yancey, C. W. C.
Test Methods for Detention and Correctional Facility Locks.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4975;   51 p. November 1992.
Available from National Technical Information Services

      correctional facilities; test methods; building technology; bullet resistance test; detention facilities; fire resistance test; impact test; lockbolt retraction test; locks

Draft test methods are presented for evaluating locks installed in detention and correctional facilities. The methods have been developed by ASTM (American Society for Testing and Materials) Committee F 33 on Detention and Correctional Facilities and are drafted in ASTM standard test method format. The NIST contribution to this effort is to assist the F 33 Committee in drafting, balloting and obtaining consensus approval for these test methods. Existing standards for residential and commercial locks have been reviewed to determine their applicability to the evaluation of locks subject to the abuse common to detention and correctional facilities. Synopses of relevant standards are presented in this report. A case is made for performing laboratory tests on prototype locks to quantify current performance levels and to establish a classification system for detention facility locks. Gaps in the knowledge base are identified and recommendations are advanced for performing a series of cyclical operations, impact and lockbolt retraction tests. The results from the recommended laboratory test program would be used to prepare a minimum performance standard for promulgation by the National Institute of Justice (NIJ). To ensure broad application of the NIJ standard, the test results would feed directly into standards-making activities of ASTM Committee F 33.

215.   Yokel, F. Y.; Knab, L.
Preliminary Report on Proposed Baffled Noise Abatement Structure.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4479;   32 p. February 1992.
Available from National Technical Information Services
PB92-172808

      acoustics; artillery noise abatement; mufflers; noise (sound)

A preliminary concept for an artillery noise abatement structure is presented. The structure is a sand-covered oval corrugated steel arch structure with transverse baffles and is designed to act like a reactive muffler. The structure can accommodate a battle tank and provides clearance for target practice. The results of an acoustical 1/200 scale model test by the Georgia Institute of Technology are presented and assessed, together with available full scale test data from other types of artillery mufflers. It is concluded that the data from the model test and other available information are encouraging enough to justify the continuation of the study of a baffled tunnel structure.

216.   Yokel, F. Y.; Mathey, R. G.
Earthquake Resistant Construction of Gas and Liquid Fuel Pipeline Systems Serving, Or Regulated By, the Federal Government. Earthquake Hazard Reduction Series 67.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4795; FEMA-233;   76 p. March 1992.
Available from National Technical Information Services

      earthquakes; codes; pipelines; liquefied natural gas; natural gas; oil storage; fuel tanks; storage tanks

The vulnerability of gas and liquid fuel pipeline systems to damage in past earthquakes, as well as available standards and technologies that can protect these facilities against earthquake damage are reviewed. An overview is presented of measures taken by various Federal Agencies to protect pipeline systems under their jurisdiction against earthquake hazards. It is concluded that the overall performance of pipeline systems in past earthquakes was relatively good, however,

older pipelines and above-ground storage tanks were damaged in many earthquakes. Modern, welded steel pipelines performed well, however, damage occurred in areas of major ground displacements. Available standards and regulations for gas pipelines do not contain seismic provisions. Standards and regulations for liquid fuel pipelines contain only general references to seismic loads. Standards and regulations for above-ground fuel storage tanks and for liquefied natural gas facilities contain explicit seismic design provisions. It is recommended that a guideline for earthquake resistant design of gas and liquid fuel pipeline systems be prepared for Federal Agencies to ensure a uniform approach to the protection of these systems.

217. Yokel, F. Y.; Tanner, A. B.
Site Exploration for Radon Source Potential.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5135; 73 p. December 1992.
Available from National Technical Information Services
PB93-162972

radon; advection; building technology; diffusion; permeability; radium activity concentration; radon availability; radon source potential; soil exploration; soil testing

Proposed measurement methods and test procedures and tentative protocols for the assessment of the radon source potential of building sites and fill materials are presented. The proposed protocols are based on repeatable measurements of invariant soil properties, with corrections for typical prevailing environmental conditions. The measured or estimated soil properties are: the radium activity concentration per unit dry mass of the soil; the emanation coefficient; the inplace dry density; the porosity; and the dry gas permeability. Three specific field exploration methods are proposed: The "SPT" method, which utilizes the Standard Penetration Test (ASTM D 1586); a manual procedure, whereby a soil sample is extracted from an auger hole or excavation and saved for laboratory analysis; and a soil gas extraction test, where an in situ measurement of soil gas permeability and radon activity concentration is linked with measurements of in-place dry density and natural water content. The proposed test and site exploration procedures can be readily integrated with present geotechnical engineering practice. An empirically-based expression for a radon source potential index is proposed. The index is used to rate the radon source potential of building sites and fill materials.

218. Zarr, R. R.; Nguyen, T.
Effects of Humidity and Elevated Temperature on the Density and Thermal Conductivity of a Rigid Polyisocyanurate Foam.
National Institute of Standards and Technology, Gaithersburg, MD
Society of the Plastics Industry (SPI). Polyurethanes 92. Annual Technical/Marketing Conference, 34th. 1992, 422-430 pp, 1992.

polyisocyanurate foam; rigid foams; humidity; temperature effects; density effects; thermal conductivity

Measurements of apparent thermal conductivity are presented for specimens of rigid polyisocyanurate (PIR) foam cut from a commercial insulation product and aged in air at 60 deg C and different humidities. Eight specimens, nominally 600 by 600 mm, were prepared from two boards (1.2 by 2.4 by 0.05 m) of rigid PIR foam blown with trichlorofluoromethane (CCl3F) and having permeable organic-inorganic facers. Facers and excess foam were removed by sanding the specimens to a thickness of 27.9 + 0.1 mm. Four specimens were placed in ambient conditions of 22 deg C and 40% relative humidity (RH). The remaining four specimens were each placed in one of the following environments: (1) 60 deg C and <10% RH; (2) 60 deg C and 40% RH; (3) 60 deg C and 60% RH; and , (4) 60 deg C and 75% RH. Measurements of apparent thermal conductivity were conducted at 24 deg C and a temperature difference of 22 deg C using a heat-flow-meter apparatus conforming to ASTM Test Method C 518. Measurements were conducted for a period of 357 days at approximately 50 day intervals. Aging curves of specimen mass, volume, density, and thermal conductivity for rigid PIR foam are presented and implications of changes in these properties are discussed in the paper. Supplemental measurements using Fourier transform infrared spectroscopy and scanning electro microscopy are also described in the paper.

219. Zhou, L.
Solid Fuel Flame Spread and Mass Burning in Turbulent Flow.
California Univ., Berkeley
NIST-GCR-92-602; 232 p. March 1992.

solid fuels; flame spread; turbulent flow; ceilings; floors; paper; plastics; polymethylmethacrylate

An experimental study has been carried out to investigate the controlling mechanisms of solid fuel flame spread and mass burning in turbulent flows. The effects of flow velocity, turbulence intensity and buoyancy on concurrent and opposed flame spread rate and surface regression rate have been examined in both floor and ceiling configurations. It is found that for opposed flows, the flame spread rate of thermally thick PMMA sheet increases initially with the flow velocity, reaches a peak value and then decreases as the flow velocity increases further. The flow turbulence effect is to increase the flame spread rate initially and then decreases it at higher turbulence intensity. The flame spread rate of thermally thin paper sheet in an opposed flow decreases monotonically with the flow velocity and turbulence intensity. The flow turbulence also has a significant effect on the flame extinction conditions, resulting in a smaller extinction velocity for larger flow turbulence intensity. For concurrent flow flame spread, it is found that the flow turbulence decreases the flame spread rate for both floor and ceiling geometries, mainly as a result of the flame length shortening at high turbulence intensity. It is also found that flow velocity intensifies the spread of the flame. The experimental data of flame spread rate, flame length and surface heat flux agree well with the formula obtained from a simplified thermal model, indicating that the heat transfer from flame to solid surface is the dominant controlling mechanism in the turbulent concurrent flame spread and, that the gas phase chemical reaction is of secondary importance. For solid fuel mass burning, it is found that the solid fuel surface regression rate decreases with the downstream distance and the flow velocity in both floor and ceiling configurations. The flow turbulence increases the surface regression by enhancing the mixing and bringing the flame closer to the solid surface. Empirical correlations between the non-dimensional surface regression rate and the non-dimensional flow parameter are obtained, which indicates the possibility of incorporating the flow turbulence intensity explicitly in a non-dimensional analysis or a numerical simulation of the problem. The results from floor and ceiling geometries are compared to determine the effect of buoyancy on flame spread and mass burning. It is shown that for ceiling configuration, buoyancy enhances the heat transfer from the flame to the solid surface by pushing the flame closer to the wall. However, it also causes the gas phase chemical reactions to proceed less completely through insufficient gas mixing and surface quenching.

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